

November 2007

Final Supplemental Environmental Impact Statement

Including Appendices A through G

Lake Okeechobee Regulation Schedule



**U.S. Army Corps of Engineers
Jacksonville District**

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Lake Okeechobee Regulation Schedule Study Lake Okeechobee, Florida

Proposed Action: To implement an interim regulation schedule for Lake Okeechobee

Type of Statement: Final Supplemental Environmental Impact Statement

Lead Agency: Jacksonville District, U.S. Army Corps of Engineers

Abstract: This Final Supplemental Environmental Impact Statement supports the proposed operational changes to the Lake Okeechobee Regulation Schedule. Over the past few years, due to heavy rainfall and numerous hurricanes, the lake stage has reached, and sometimes remained at higher than normal levels. Higher than desirable lake levels frequently result in high volume regulatory releases to the Caloosahatchee and St. Lucie estuaries. These high lake stages and high volume releases to the estuaries contribute to disrupted productivity in the ecological communities of Lake Okeechobee and its estuaries. All alternatives evaluated would manage Lake Okeechobee at a lower level than the current water regulation schedule. The issue of public health and safety, related to concerns regarding the integrity of the Herbert Hoover Dike (HHD) surrounding the lake, is the dominant factor in the decision making process to select a preferred alternative regulation schedule. The preferred alternative regulation schedule attempts to balance competing objectives including flood control, water supply, navigation and enhancement of fish and wildlife resources. However, with a multi-purpose project, managing for better performance of one objective often reduces the ability to satisfy other competing objectives. The regulation schedule recommended represents the best operational compromise at this time to improve the environmental health of certain major ecosystems, while providing for public health and safety as it pertains to the Lake Okeechobee Regulation Schedule and the HHD. The Corps expects to operate under this interim schedule until the earlier of (1) implementation of a new Lake Okeechobee schedule as a component of the system-wide operating plan to accommodate the Comprehensive Everglades Restoration Plan (CERP Band 1 projects) and the State of Florida's fast track Acceler8 projects, or (2) completion of HHD seepage berm construction or equivalent dike repairs for reaches 1, 2 and 3.

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The official closing date for the receipt of comments is 30 days from the date on which the notice of availability of this Final Supplemental Environmental Impact Statement appears in the Federal Register. The expected Federal Register date is November 16, 2007.

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EXECUTIVE SUMMARY

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT ON LAKE OKEECHOBEE REGULATION SCHEDULE LAKE OKEECHOBEE, FLORIDA

The U.S. Army Corps of Engineers (Corps) is proposing to implement a new regulation schedule for Lake Okeechobee and the Everglades Agricultural Area. The regulation schedule will become part of the Water Control Plan for Lake Okeechobee, which is a feature of the Central and Southern Florida (C&SF) Project. This Supplemental Environmental Impact Statement (SEIS) supports the proposed operational changes to the current Water Control Plan. The SEIS explains the recommended Water Control Plan changes, and provides technical information explaining the basis for the recommendation. The SEIS includes a description of the alternative plans considered, an evaluation of the alternative plans, and a description of environmental effects and the projected impacts of the recommended Water Control Plan on the various purposes of Lake Okeechobee and the C&SF Project. The Water Control Plan will be finalized after the public involvement process associated with its development or change is complete.

Background

Lake Okeechobee, a large, natural, freshwater lake, is considered the heart of the water resources system in south Florida. The Herbert Hoover Dike (HHD) and several water control structures allow management of the lake to meet different objectives, including flood control, water supply, and environmental enhancement. Lake Okeechobee benefits south Florida by storing water during wet periods for subsequent environmental, urban and agricultural needs during dry periods.

Over the past few years, Lake Okeechobee has experienced above average lake levels. These extended periods of high water levels within Lake Okeechobee have been identified as causing stress to the structural integrity of the HHD that surrounds the lake, as well as the lake's natural habitat. Additionally, high water levels in the lake have led to high volume freshwater releases to the coastal estuaries, causing stress to marine habitats. To lessen some of the impacts to the environment from high volume releases, and accommodate for HHD structural limitations, a lower lake regulation schedule is necessary.

The current Lake Okeechobee Regulation Schedule (LORS), referred to as Water Supply and Environment (WSE) was supported in a 1999 Environmental Impact Statement (EIS), with a Record of Decision (ROD) signed on July 7, 2000. Since implementation of the WSE schedule, it has been determined that improvements to

performance of the regulation schedule could be achieved. In 2003-2005, Lake Okeechobee experienced consecutive very wet summers. During this time, water managers were faced with regulation schedule constraints under the current water control plan that provided them minimal operating flexibility to adapt to real time effects. In order to improve lake operations under the unusually-wet conditions, a series of operational deviations were approved and implemented between 2003 and 2006. Even under the operational deviations, Lake Okeechobee still experienced continued high water levels that posed structural integrity and public safety issues with the HHD, caused adverse effects to the lake's ecosystem, and contributed to harmful freshwater releases to the Caloosahatchee and St. Lucie estuaries. Environmentalists and scientists within the surrounding communities strongly advocated lowering the lake levels and reducing the large freshwater releases to the estuaries.

To address environmental concerns and HHD integrity issues, in 2005, the Lake Okeechobee Regulation Schedule Study (LORSS) was initiated which focused on alternative schedules designed to lower the normal operating limits of Lake Okeechobee. The study developed several alternatives, which resulted in the selection of Alternative 1bS2-m as the Preferred Alternative. Alternative 1bS2-m was supported in a draft SEIS. Notice of Availability of the draft SEIS appeared in the Federal Register on August 18, 2006. During the draft SEIS public review period, numerous public comments were received. The majority of the public comments centered on the need for improving Alternative 1bS2-m as it related to the Caloosahatchee Estuary performance. While the Preferred Alternative, 1bS2-m, did well in lowering lake operating limits, the public was concerned that the schedule did not adequately reduce the high freshwater releases to the Caloosahatchee Estuary on Florida's west coast.

Based on consideration of public comments received, the Corps made a decision to complete additional alternative plan formulation and subsequent hydrologic simulation modeling in an attempt to improve the Caloosahatchee Estuary performance, while achieving other study objectives. Since additional formulation and modeling was done, which resulted in three new alternatives, it was necessary to revise the August 2006 draft SEIS, instead of finalizing the document. A revised draft SEIS was prepared which evaluated the new array of alternatives, and incorporated the responses to the many comments received on the August 2006 draft SEIS. Subsequently, this final SEIS was prepared which has incorporated comments received on the revised draft SEIS.

Need or Opportunity

There is a need to manage Lake Okeechobee at a lower operation schedule. Evidence of this has been clearly established for ecological reasons, such as continued deterioration of Lake Okeechobee's littoral zone and both the Caloosahatchee and St. Lucie estuaries. LORSS was initiated to address these concerns and to add flexibility to WSE. After the study was initiated, the need to manage Lake Okeechobee at lower levels was driven primarily by structural integrity issues with the HHD levee system that protects the surrounding communities from flood damage.

Major Findings and Conclusions

For a multiple purpose lake, such as Lake Okeechobee, a regulation schedule attempts to balance competing objectives including flood control, water supply, navigation and preservation of fish and wildlife resources. Thus, managing for better performance of one objective often reduces the ability to satisfy other competing objectives. An objective of the study is to minimize high lake stage events. The alternatives performed well in meeting this objective. However, there is a trade-off when decreasing the high lake stage events, which is increasing the frequency of low stage events. When water levels reach extreme low stages, there is always the potential for navigation, water supply, and fish and wildlife resource impacts throughout the study area. Lowering lake stages can also create or contribute to adverse conditions in the Caloosahatchee and St. Lucie Estuaries.

Alternatives

Two alternatives from the August 2006 draft SEIS (the Preferred Alternative 1bS2-m, and Alternative 1bS2-A) were carried forward for further modeling and refinements to better meet the objectives of the LORSS. From these two alternatives, three additional alternatives (referred to in this EIS as Alternatives C, D, and E) were developed. All of the alternatives were modeled and evaluated, and then compared to the No Action Alternative. The alternatives were evaluated using a set of performance measures and evaluation criteria that were previously developed for other studies in the study area and specifically for this study.

It should be recognized that prior to the alternative formulation and evaluation process for the revised draft SEIS and prior to the start of additional modeling, the Corps conducted a detailed review of the assumptions and data sets included in the original modeling for the 2006 draft SEIS. As with most studies, the modeling data sets and assumptions used for the LORSS evolved during the duration of the study. The additional modeling performed for the revised draft SEIS presented an opportunity to update modeling data and assumptions to ensure that the most current data sets and assumptions were considered in the evaluations of the Preferred Alternative refinements resulting from the additional plan formulation.

Preferred Alternative

The Preferred Alternative (Alternative E) recommended in this report represents the best operational compromise at this time to improve and maintain the environmental health of certain major C&SF ecosystems, while providing for public health and safety as it pertains to the LORS and the impact it has on the safe operation of the HHD.

Areas of Controversy

There will always be a level of controversy involved in the operation of a large, complex, multi-purpose project, such as Lake Okeechobee. As authorized, the project has many purposes, including flood control, water supply for agriculture, municipalities, and Everglades National Park (ENP), preservation of fish and wildlife, recreation, navigation and prevention of salt water intrusion. More often than not, trade-offs will exist in order to meet project purposes. Much controversy centered on the previous Preferred

Alternative, IbS2-m, and its potential adverse effects on the Caloosahatchee Estuary. Following release of the initial draft SEIS, there was concern with the high lake constraint set at 17.25 ft. NGVD in the modeling. Many of the comments received on the 2006 draft SEIS requested that the Corps relax the 17.25 ft. constraint for further alternative formulation and evaluation. The Corps recognized the importance of improving the estuary performance as it related to reducing undesirable high volume flows, and relaxed the 17.25 ft. constraint by instead treating it as a performance measure.

Controversy/Unresolved Issues

There is controversy with water supply stakeholders about the uncertainty of water supply performance with the recommended plan in conjunction with the SFWMD Lake Okeechobee Water Shortage Management (LOWSM) plan. Consequently, there is concern about the length of the period during which the Corps will operate under this schedule. Among those stakeholders, the Seminole Tribe has concerns about how the state will mitigate for water supply impacts.

Interim Nature of the Selected Plan

A new regulation schedule is required to respond to high lake levels that have resulted in integrity issues and concerns with the Herbert Hoover Dike (HHD), high volume releases to the estuaries, and impacts to Lake Okeechobee littoral zones. Hence, a new Lake Okeechobee Regulation Schedule was developed. LORS is intended to be an interim schedule. Because this schedule was formulated to address specific conditions existing in 2007, as circumstances change, the Corps will adapt its Lake Okeechobee operations accordingly. The Corps expects to operate under LORS until the earlier of (1) implementation of a new Lake Okeechobee schedule as a component of the system-wide operating plan to accommodate the Comprehensive Everglades Restoration Plan (CERP Band 1 projects) and the State of Florida's fast track Acceler8 projects, or (2) completion of HHD seepage berm construction or equivalent dike repairs for reaches 1, 2 and 3. The occurrence of the above referenced events are expected to allow for greater operational flexibility, potentially including higher lake levels for increased water storage. In balancing the multiple project purposes, the Corps, will timely shift from the interim LORS to a new schedule with the intent to complete any necessary schedule modifications or deviations concurrent with completion of (1) or (2).

Pending completion of rehabilitation in Reaches 1, 2 or 3, as HHD rehabilitation progresses, the Corps will evaluate the capacity to operate the Lake in a manner to provide more water storage in conjunction with achieving other project purposes. The anticipated points at which the Corps will utilize the flexibility within the schedule consistent with protection of health safety and welfare to provide additional storage include, at a minimum, completion of filling of the toe ditch, construction of the seepage berm within the existing right of way in Reach 1, and equivalent dike improvements in Reaches 2 or 3, which are currently under design. Upon changed circumstances, the Corps will provide additional storage, consistent with technical analysis, that might result from higher lake elevations. The Corps can respond to changed circumstances

by adjusting operations within LORS' operational flexibility or through schedule deviations.

The Corps will conduct appropriate National Environmental Policy Act (NEPA) analysis as it responds to new information and to support any future schedules, schedule deviations or modifications.

As required by the CERP Programmatic Regulations, projects implemented under the CERP are to be operated under a System Operating Manual and individual Project Operating Manuals. The initial System Operating Manual, which is currently in draft, will be a system-wide operating plan for CERP features as well as features of the existing Central and Southern Florida Project. In Fiscal Year 2008, the Corps and SFWMD will initiate the System Operating Manual Study to look at possible revisions to the initial System Operating Manual due to construction and operation of the CERP Band 1 projects as well as possible modifications to Lake Okeechobee operations as a result of Herbert Hoover Dike repairs. The Lake Okeechobee regulation schedule will be a priority in these revisions.

The Environmental Impact Statement analysis indicates that LORS is projected to adversely impact water supply at low lake levels with the current SFWMD water supply triggers. During LORS implementation, the Corps will utilize the flexibility within the schedule to take advantage of potential opportunities to increase water supply benefits considering all other project purposes, antecedent conditions and forecast conditions. If necessary to address unforeseen circumstances, the Corps may implement planned or emergency deviations to LORS.

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LIST OF ACRONYMS

>	Greater than
<	Less than
A	
ASR	Aquifer Storage and Recovery
B	
BA	Biological Assessment
BO	Biological Opinion
C	
C&SF	Central and Southern Florida
CAA	Clean Air Act
CAR	Coordination Act Report
CERP	Comprehensive Everglades Restoration Plan
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CLA	Classification Limit Adjustment
cm	centimeter
Corps	U.S. Army Corps of Engineers
CR	County Road
CSSS	Cape Sable Seaside Sparrow
CWA	Clean Water Act
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
D	
Decomp	Decompartmentalization
E	
EA	Environmental Assessment
EAA	Everglades Agricultural Area
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ENP	Everglades National Park
E.O.	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
F	
FDEP	Florida Department of Environmental Protection
FFWCC	Florida Fish and Wildlife Conservation Commission
FMP	Fishery Management Plan

FONSI	Finding of No Significant Impact
ft	foot/feet
G	
GMFMC	Gulf of Mexico Fishery Management
H	
HAB	Harmful Algal Blooms
HHD	Herbert Hoover Dike
HTRW	Hazardous, Toxic and Radioactive Waste
I	
IRL	Indian River Lagoon
K	
km	kilometer
L	
LEC	Lower East Coast
LECSA	Lower East Coast Service Area
LOPA	Lake Okeechobee Protection Act
LONIN	Lake Okeechobee Net Inflow
LONINO	Lake Okeechobee Net Inflow Outlook
LOOPS	Lake Okeechobee Operations Screening Model
LORS	Lake Okeechobee Regulation Schedule
LORSS	Lake Okeechobee Regulation Schedule Study
LOSA	Lake Okeechobee Service Area
LOWSM	Lake Okeechobee Water Shortage Management
LWL	Lake Worth Lagoon
M	
MISP	Master Implementation Sequencing Plan
mph	miles per hour
MRR	Major Rehabilitation Evaluation Report
MSCO	Multi-season Climate Outlook
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
mt/yr	metric tons per year
N	
NEPA	National Environmental Policy Act
*NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOA	Notice of Availability
NOI	Notice of Intent

N NTO Non-typical Temporary Operation

P

PM Performance Measure
PDSI Palmer Drought Severity Index
PDT Project Delivery Team
POR Period of Record
ppb parts per billion
ppt parts per thousand

R

RECOVER Restoration, Coordination and Restoration
ROD Record of Decision

S

SAFMC South Atlantic Fishery Management Council
SAV Submerged Aquatic Vegetation
SCO Seasonal Climate Outlook
SEIS Supplemental Environmental Impact Statement
SFWMD South Florida Water Management District
SFWM Model South Florida Water Management Model
SHPO State Historic Preservation Officer
SSM Supply Side Management
STA Stormwater Treatment Area

T

THC Tributary Hydrologic Condition
TMDL Total Maximum Daily Loads

U

U.S. United States
USACE U.S. Army Corps of Engineers
USFWS United States Fish and Wildlife Service

W

WCA Water Conservation Area
WMA Wildlife Management Area
WRAC Water Resources Advisory Commission
WRDA Water Resources Development Act
WSE Water Supply and Environment
WST Water Shortage Trigger

*The elevations described in this document refer to feet above mean sea level, using the standard National Geodetic Vertical Datum Plane of 1929.

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SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR THE LAKE OKEECHOBEE REGULATION SCHEDULE

1. PROJECT PURPOSE AND NEED

1.1. PROJECT AUTHORITY

Authority to complete this study was granted under Section 310 of the 1990 Water Resources Development Act (WRDA) which reads in part: "...(1) CENTRAL AND SOUTHERN FLORIDA-The Chief of Engineers shall review the report of the Chief of Engineers on central and southern Florida, published as house Document 643, 80th Congress, 2nd Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operations for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operations."

1.2. PROJECT LOCATION

Lake Okeechobee is located in south central Florida, and occupies portions of, Glades, Hendry, Martin, Okeechobee, and Palm Beach counties (Figure 1-1). Lake Okeechobee has an area of approximately 730 square miles with its approximate center near 26° 56' 55" north latitude and 80° 56' 34" west longitude. The area that may be affected by the proposed alternative lake regulation schedules includes much of south Florida beyond the bounds of Lake Okeechobee proper. For the purposes of this study, it has been determined that substantive effects may be regional in nature and importance, but perhaps due to the restricted operational changes being proposed, are not limitless in scope and effect. Hydrologic modeling, using the South Florida Water Management Model (SFWMM), indicate that the southern Water Conservation Areas (WCAs), including WCA 3A below I-75 (Alligator Alley), WCA 2B, 3B, and the Everglades National Park (ENP) are not significantly affected by the operational changes being proposed to the Lake Okeechobee Regulation Schedule (LORS). The areas considered to be most affected and which shall receive the greatest scrutiny in terms of impact assessment are Lake Okeechobee, particularly within the littoral and marsh areas of the lake, and major downstream estuaries including the St. Lucie and Caloosahatchee estuaries. To a lesser degree, other areas considered to be affected are within the Everglades Agricultural Area (EAA), and in the northern WCAs, including WCA 3A north of I-75, WCA 2A, and the Arthur R. Marshall Loxahatchee National Wildlife Refuge (WCA 1), and the Lake Worth Lagoon. Figure 1-2 provides an overall image of the study area including its proximity within the central and south Florida ecosystem.

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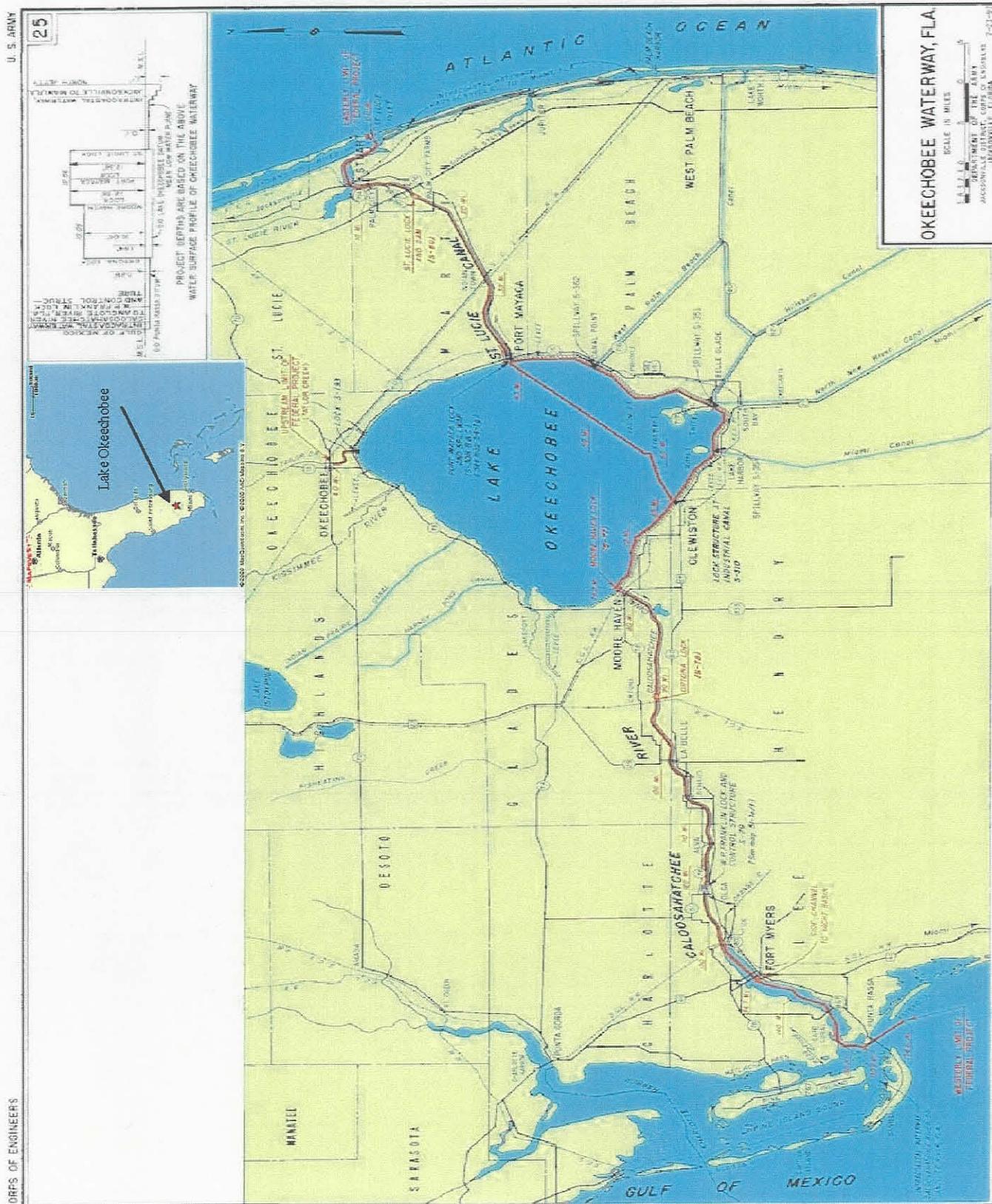


FIGURE 1-1: LOCATION MAP

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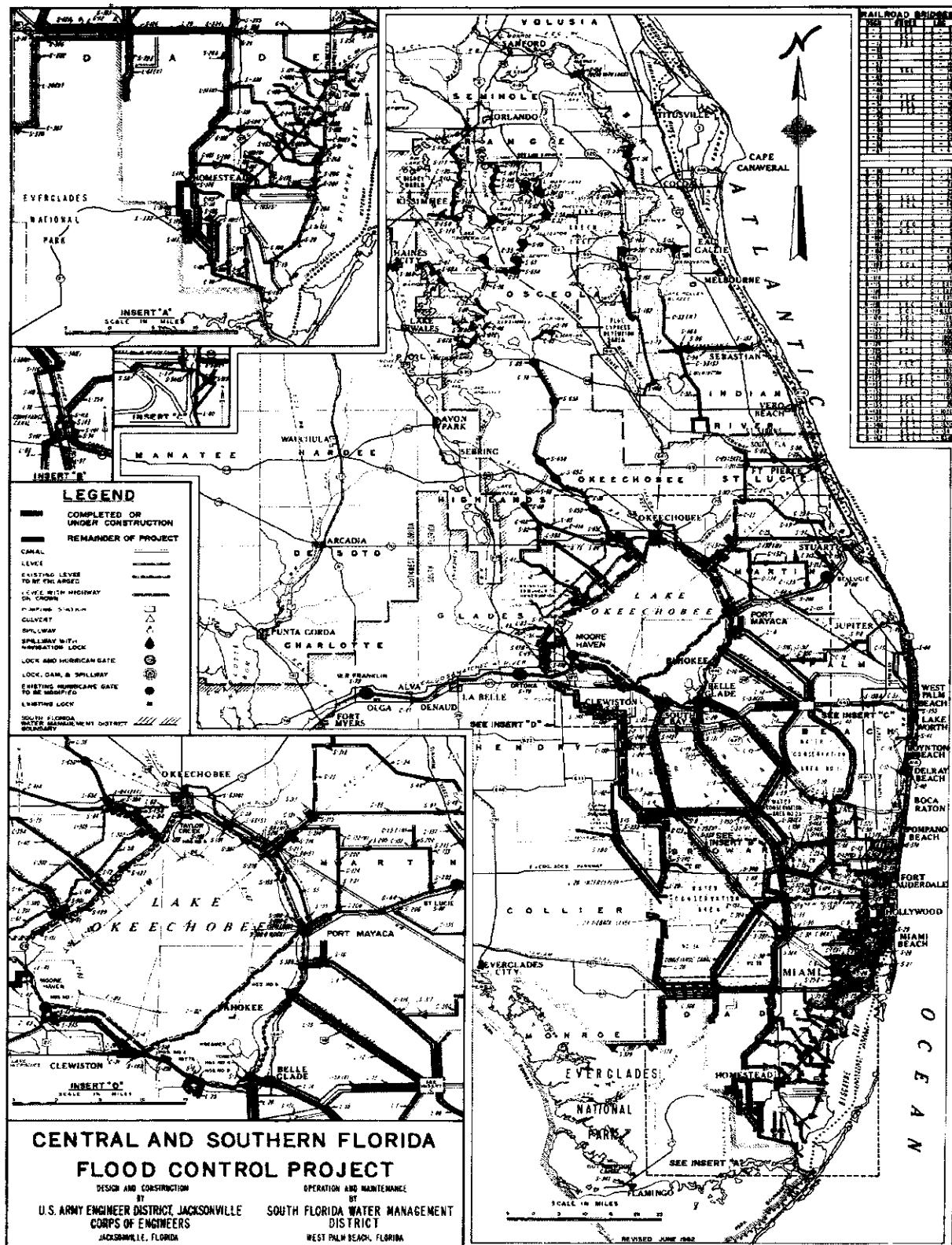


FIGURE 1-2: C&SF PROJECT MAP

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Part of the Okeechobee Waterway, the St. Lucie Canal is the main eastern flood control outlet for Lake Okeechobee. The St. Lucie Estuary is located within portions of both Martin and St. Lucie counties on the southeast coast of Florida. The two forks of the St. Lucie Estuary, the North Fork and South Fork, flow together near the Roosevelt Bridge at the City of Stuart, and then flow eastward approximately six miles to the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet.

The Caloosahatchee River is the only flood-control outlet leading west from Lake Okeechobee, part of the Okeechobee Waterway, and combined with the St. Lucie Canal, the only navigable passage between the Gulf of Mexico and the Atlantic Ocean. The river extends approximately 70 miles from Lake Okeechobee, through the Caloosahatchee Estuary, to the lower Charlotte Harbor Basin at San Carlos Bay. The Caloosahatchee River passes through parts of Glades, Hendry, and Lee counties.

The EAA, located south of Lake Okeechobee within eastern Hendry and western Palm Beach counties, encompasses an area totaling approximately 718,400 acres (1,122 square miles) of highly productive agricultural land comprised of rich organic peat or muck soils. A small portion of EAA mucklands is found in western Martin County. The EAA is considered one of Florida's most important agricultural regions. The EAA extends south from Lake Okeechobee to the northern levee of WCA 3A. Its eastern boundary extends to the L-8 Canal. The L-1, L2 and L-3 levees represent the EAA's westernmost limits.

The WCAs cover 1,372 square miles and are located south of Lake Okeechobee and the EAA. WCA 1, also known as the Arthur R. Marshall Loxahatchee National Wildlife Refuge, includes 227 square miles of Everglades wetland habitat. WCA 2, the smallest of the three WCAs, encompasses approximately 210 square miles. The area is divided into two cells by a levee constructed in 1961. The north cell, WCA 2A, covers 173 square miles, and the south cell, WCA 2B, covers 37 square miles. WCA 3, the largest of the WCAs covers an area of 915 square miles.

The Lake Worth Lagoon, located in Palm Beach County, is another estuary of importance within the study area. The Lake Worth Lagoon, centrally located in the county is approximately 20 miles in length, and averages approximately 0.4 miles in width, and six to ten feet in depth (Palm Beach County Department of Environmental Resources Management [PBDERM], 1998). The Lake Worth Lagoon is separated from the Atlantic Ocean by a barrier island. Major freshwater drainage into the estuary occurs from many canal systems. The C-51 canal is the largest inflow of fresh water discharging into the lagoon (PBCDERM, 1998). The C-51 basin includes the West Palm Beach Canal which extends from Lake Okeechobee south and east to the coastline where it empties into Lake Worth Lagoon.

1.3. PROJECT NEED OR OPPORTUNITY

There is a need to manage Lake Okeechobee at a lower lake schedule. Evidence of this need has been clearly established for ecological reasons, such as the continued deterioration of Lake Okeechobee's littoral zone and both the Caloosahatchee and

St. Lucie estuaries. The need to manage the lake lower is also driven by integrity issues with the Herbert Hoover Dike (HHD) levee system that protects the surrounding communities from flood damage.

1.4. AGENCY GOAL OR OBJECTIVE

The agency goal is to implement a new interim regulation schedule that would ensure public health and safety while improving the health of Lake Okeechobee and the St. Lucie and Caloosahatchee estuaries, with minimal or no impact to the competing project (lake) purposes. Study objectives consistent with this goal have been determined as follows:

- a. Ensure public health and safety;
- b. Manage Lake Okeechobee at optimal lake levels to allow recovery of the lake's environment and natural resources;
- c. Reduce high regulatory releases to the estuaries;
- d. Continue to meet Congressionally authorized project purposes including, flood control, water supply, navigation, fish and wildlife enhancement, and recreation.

1.5. BACKGROUND AND RELATED ENVIRONMENTAL DOCUMENTS

The regulation of Lake Okeechobee water levels is performed by the U.S. Army Corps of Engineers (Corps), in consultation with the South Florida Water Management District (SFWMD). Lake Okeechobee is managed as part of the Central and Southern Florida (C&SF) Project for water supply and flood protection needs of the rapidly growing population of south Florida. The main inflows to Lake Okeechobee are the Kissimmee River, Taylor Creek-Nubbin Slough, Indian Prairie Canal, Harney Pond Canal, and Fisheating Creek. The main outflows east and west are the St. Lucie Canal, and the Caloosahatchee River, which comprise the largest outflow capacity. The main outflows south are through the Miami Canal, North New River Canal, Hillsborough Canal, and the West Palm Beach Canal. Inflows to Lake Okeechobee frequently exceed total outflow capacity. The HHD and several water control structures allow management of Lake Okeechobee to meet project purposes which include flood control, water supply, navigation, recreation and environmental enhancement.

The tool used to perform Lake Okeechobee operations is referred to as a regulation schedule. A regulation schedule is a guideline for water managers to use in regulating the inflow and outflow of water through the various water control structures, i.e. pumps, spillways and locks. Regulation schedules for Federal water resources projects are included in water control manuals prepared in accordance with engineering regulations, and are accompanied by the appropriate environmental documentation required under the National Environmental Policy Act (NEPA). Since construction of the C&SF Project, there have been several authorized LORSS to accommodate structure capabilities, such as HHD (levee) height, and to attempt to address the water supply needs of the growing population of south Florida. During the early 1970s, levee improvements were made so that Lake Okeechobee could safely handle the 15.5 to 17.5 foot authorized regulation schedule. In 1978, consultation regarding the new schedule was conducted with the United States Fish and Wildlife Service (USFWS). This consultation resulted in

issuance of a Fish and Wildlife Coordination Act Report (CAR), and a Biological Opinion.

In 1991, the SFWMD requested that the Corps implement an interim 15.65 to 16.75 ft. National Geodetic Vertical Datum (NGVD) schedule. In 1994, an Environmental Assessment (EA) resulting in a Finding of No Significant Impact (FONSI) was prepared for the schedule referred to as Run 25. Lake Okeechobee was operated under the Run 25 schedule until the current schedule, Water Supply and Environment (WSE) was approved in 2000. A Final Environmental Impact Statement (EIS) supporting the WSE schedule was completed in 1999, with a Record of Decision (ROD) signed in July 2000.

When the WSE schedule was approved in 2000, south Florida was in the beginning of a severe drought that lasted through much of 2001. Lake Okeechobee experienced a record low water level of 8.97 ft. NGVD on May 24, 2001 (update: new record low water level of 8.82 ft. NGVD was set on July 2, 2007). Then to the other extreme, Lake Okeechobee experienced consecutive very wet summers in 2003-2005, with the water level reaching a high of 18.02 ft. NGVD on October 13, 2004. Much of the wet weather pattern was a result of the historically significant hurricane seasons in 2004 and 2005. Years 2004 and 2005 are ranked eighth and ninth for Lake Okeechobee's highest net inflow during the wet season (June-October) since 1914.

In the relatively short period of time since the WSE schedule was approved, some weaknesses in the schedule became evident. High lake levels were a result of the wetter than normal conditions from 2003-2005. WSE did not allow for sufficient releases to be made under the hydrological conditions that existed at that time. Due to the continuing problems with high water elevations under the WSE schedule, in 2003, the Corps officially deviated from the WSE schedule in an attempt to lower Lake Okeechobee. As the recent past has shown, the WSE regulation schedule limits releases from Lake Okeechobee during certain hydrological conditions when water levels are high and during some periods when the lake's littoral zone and estuaries would have benefited from such releases. Not only is this a concern for lake and estuary ecology, but also for integrity issues with the HHD. The deviation was made in an attempt to lower Lake Okeechobee by making relatively small (Level 1) pulses to the estuaries. It was at this time that public concern for the surrounding levee system, the health of Lake Okeechobee and the downstream estuaries led to commitments by executive management of the Corps to re-examine the WSE regulation schedule.

The Corps initiated a multi-phase effort to improve the WSE. The first phase, which began in 2004, implemented a modification to the schedule to increase the flexibility and opportunities to make releases when the lake stage is between the "no regulatory discharge" and "discharge maximum practicable" release zones. The Corps made the schedule modification as a temporary planned deviation referred to as the Classification Limit Adjustment (CLA), which was implemented to adjust classifications of the hydrologic indicators and forecasts included in the regulation schedule. An EA was prepared in December 2004 (incorporated by reference), with a FONSI signed on January 25, 2005, for the action. The intent of the CLA was to help lower above-

average lake levels and to improve ecological conditions within Lake Okeechobee's littoral zone. However, the CLA has not affected the regulation schedule because the appropriate trigger conditions necessary to implement the deviation seldom occur.

Phase 2 of the multi-phase effort to modify the regulation schedule began in July 2005, and is the current Lake Okeechobee Regulation Schedule Study (LORSS) that led to a draft Supplemental Environmental Impact Statement (SEIS) dated August 2006 (incorporated by reference). The Preferred Alternative identified in the August 2006 draft SEIS prompted numerous comments during the public review period. The majority of the public comments centered on the need to improve the performance of the identified Preferred Alternative, referred to as 1bS2-m. In particular, the concerns were that the Preferred Alternative did not adequately address the high volume freshwater releases to the Caloosahatchee Estuary. Based on consideration of the public comments, additional alternative plans were formulated and additional modeling was performed in an attempt to achieve better alternative performance in the model simulations. This revised draft SEIS evaluates the environmental effects of the new alternatives.

In Fiscal Year 2008, the Corps and SFWMD will initiate Phase 3 efforts referred to as the System Operating Manual Study to look at possible revisions to the initial System Operating Manual due to construction and operation of the CERP Band 1 projects as well as possible modifications to Lake Okeechobee operations as a result of HHD repairs. The LORS will be a priority in these revisions.

The recommendation to adopt a new interim regulation schedule for Lake Okeechobee as a result of this study should be viewed as one step in the longer process of developing a LORS that will take into account the CERP Band 1 projects, as well as HHD repairs. Adjusting the lake's regulation schedule now will change the way the regional system is operated, but the larger problems now existing in the system can only be solved by adding water storage features on a regional scale which is being addressed by the CERP.

1.6. DECISIONS TO BE MADE

A major concern with the present regulation schedule, WSE, is the structural stability of the HHD during high water stages. As such, a decision was made to only evaluate alternative plans that triggered maximum regulatory releases one-foot lower than the WSE regulation schedule requirement. The heightened concern with HHD was emphasized after several hurricanes passed through south Florida during 2004 and 2005, as well as the levee damage around New Orleans caused by Hurricane Katrina in 2005. Prior to these devastating hurricanes, the Corps conducted a lengthy study of the HHD condition which resulted in a 1999 report titled "Major Rehabilitation Evaluation Report" (MRR). This report documents the condition of the dike, and identifies needed repairs. A table within the MRR identifies the combined probability of levee breach at different lake elevations. Under WSE (elevation 18.53 ft.), there is a 55% probability of levee breach. In response to the findings in the MRR, a Major Rehabilitation Project was approved, and HHD rehabilitation is currently underway. HHD rehabilitation

construction, as well as the State's independent report of the technical inspection of the HHD released in 2006, prompted much attention during the LORSS. The State's independent report essentially validated the Corps previous findings from the MRR that the HHD is in need of rehabilitation. After the State's independent report was publicly released, the Corps received a letter of concern from the Governor of Florida (Pertinent Correspondence, Appendix H). The Governor's concern was the potential failure of the dike and the effects a failure could have on the communities around Lake Okeechobee.

The Corps considers public health and safety as its highest priority. The recent attention given to the HHD stability issue underscores the importance of the implementation of the rehabilitation plan, as well as the plan to develop a new regulation schedule. HHD integrity problems such as seepage, piping, and boils are exacerbated when the lake elevation approaches 18.5 ft., NGVD (USACE, 2005). As a result, the LORSS only considered alternatives that would allow Lake Okeechobee to be managed at a lower average level year-round compared to the WSE regulation schedule. Other important considerations for this study were the environmental needs of Lake Okeechobee, the Caloosahatchee and St. Lucie estuaries, and the greater Everglades (including the WCAs). The work performed for this study consisted of identifying the effects (both beneficial and adverse) associated with the alternatives developed for the LORSS. Broadly, the effort involved:

- a. Identifying all environmental, fish and wildlife, cultural and recreational resources in the study area;
- b. Assessing the effects of the alternative regulation schedules on these resources;
- c. Quantifying impacts to the competing lake management objectives such as flood protection, water supply, recreation and navigation;
- d. Evaluating the socio-economic impacts associated with the alternative regulation schedules; and
- e. Preparing the required documentation including graphics to present the study's findings and recommendations.

1.7. PUBLIC CONCERNS

Through numerous public meetings and coordination opportunities, agencies, local officials, residents, and environmental groups have expressed their concern over the ecological health of Lake Okeechobee and the coastal estuaries, and are looking to the Corps to resolve the problem. Environmentalists and scientists within the environmental community are strongly advocating for lowering the lake levels and reducing the high volume releases to the estuaries. Agricultural and municipal water supply interests are equally concerned with the potential consequences of managing the lake at lower levels. With these concerns in mind, this study was implemented as an intermediate step to attempt to resolve these issues solely through the current Federal authority to make operational modifications. The new alternative regulation schedule can only achieve minor improvement in the timing of water releases and cannot result in significant improvement until more storage is available within the system.

1.8. SCOPING AND ISSUES

1.8.1. ISSUES EVALUATED IN DETAIL

The following issues were identified during scoping and by the preparers of this SEIS to be relevant to the proposed action and appropriate for detailed evaluation:

- Public health and safety
- Flood control
- Water supply
- Impacts to Lake Okeechobee, Everglades and estuarine biota
- Endangered and threatened species
- Water quality
- Navigation

1.8.2. ISSUES SCREENED FROM DETAILED ANALYSIS

The following issues were not considered as important to the proposed action based on scoping and the professional judgment of the preparers of this SEIS:

- Historic properties
- Air quality
- Noise pollution
- Hazardous, toxic and radioactive waste (HTRW)

1.9. PERMITS, LICENSES, AND ENTITLEMENTS

Clean Water Act of 1972

As the proposed action is strictly of an operational nature, and does not involve any new discharge or construction activity, water quality certification from the State of Florida is not required. Furthermore, as there are no structural components contained in the proposed action and no dredge and fill operations being considered, a Section 404 (b) Evaluation is not necessary.

Coastal Zone Management Act

This action has been reviewed for consistency with the State's Coastal Zone Management (CZM) Program, pursuant to the Coastal Zone Management Act (CZMA), 16 U.S.C., 1451-1464, as amended.

2. FORMULATION OF ALTERNATIVES

This section describes in detail the No Action Alternative, the proposed action, and other reasonable alternatives that were studied in detail. Section 5, Affected Environment, presents the beneficial and adverse environmental effects of all alternatives in comparison form, providing a clear basis for the decision maker and the public to choose among the options.

2.1. WHAT IS A REGULATION SCHEDULE?

As part of the operation of the C&SF Project, the Corps establishes a water regulation schedule for Lake Okeechobee. A regulation schedule is a guideline for water managers to use in regulating the inflow and outflow of water through the various water control structures, i.e. pumps, spillways and locks.

The term "regulation schedule" refers to a compilation of operating criteria, guidelines, rule curves and specifications that govern storage and release functions of a reservoir. A regulation schedule is a tool used by water managers to manage the water levels. Typically, a regulation schedule has water level thresholds which vary with the time of year and trigger discharges. The threshold lines of regulation schedules define the release zones and are traditionally displayed graphically. Additionally, a corresponding table is typically used to identify the structure discharge rules for release zones. Regulation schedules for Corps water resources projects are included in water control manuals prepared in accordance with engineering regulations, and are accompanied by the appropriate NEPA-required documentation. The authority for approving water control manuals rests with the appropriate U.S. Army Corps of Engineers Division Commander. For this study, the proposed modification to the LORS will be submitted for review and approval to the commander of the Corps of Engineers South Atlantic Division after conclusion of the public and agency review process.

The LORS has been, and will continue to be, designed to balance multiple, and often competing, project purposes and objectives. Thus, managing for better performance of one objective often lessens performance of competing objectives. For example, higher regulation schedules tend to benefit water supply, but may increase the risk to public health and safety, and can harm the ecology of the lake. Lower lake schedules may produce lake levels more desirable for lake ecology and improved flood protection, but reduce water supply potential. Lowering lake water levels also has the potential to adversely affect estuarine systems receiving lake discharges. Therefore, the LORS is not developed to optimize performance of any single project purpose, but rather attempts to balance the performance of the multiple project purposes.

Water levels in Lake Okeechobee are driven largely by climatic conditions. The difficulty with Lake Okeechobee is inflows to the lake frequently exceed total outflow capacity, which sometimes causes the lake to rise very quickly. These sudden rises in water level may trigger discharges through the major outlets in an effort to control excessive buildup of water in Lake Okeechobee. The timing and magnitude of these

releases is not only important for preserving flood protection of the region, but also for protecting the natural habitats of the downstream estuaries.

While providing for Federal project purposes, the LORS also provides for the rights of water allocation that rest with the State of Florida. In the case of the C&SF project, the state agency responsible for allocating water is the SFWMD. The SFWMD is responsible for water supply allocation from Lake Okeechobee. Releases may be municipal and agricultural water supply, aquifer protection, to maintain appropriate salinity envelope in the estuaries, environmental releases south to the Everglades, or any other beneficial uses the SFWMD deems appropriate. The State's decision regarding appropriating water supply allocations is not determined by the Corps, unless the release would interfere with Federal project purposes.

2.2. DEVELOPMENT OF ALTERNATIVE PLANS

While the issues that surround the implementation of a regulation schedule for Lake Okeechobee are very complex, as are the various scientific and engineering models used, the planning process is relatively straightforward. Various lake regulation schedule alternatives were developed and proposed to replace the existing schedule, WSE. At the beginning of the LORSS, three conceptual alternatives and the No Action Alternative were formulated and evaluated by the LORSS Project Delivery Team (PDT). Alternatives 1 and 2 were conceptual alternatives that were developed by the SFWMD and the Corps respectively, and were used as starting points in the alternative formulation development process. In addition to Alternatives 1 and 2, an alternative from the 1999 LORSS (referred to as Run 22AZE in the 1999 study) was pulled forward into the new LORSS as Alternative 3. This alternative was pulled forward into the current LORSS at the request of resource management agencies on the PDT. Alternatives 1, 2 and 3 were then modeled, and evaluated against performance measures established at the beginning of the study. Performance measures were developed for Lake Okeechobee, Caloosahatchee Estuary, St. Lucie Estuary, Lake Worth Lagoon, water supply, public safety, navigation, and the greater Everglades.

Initial Alternative Evaluation Results

The PDT conducted an evaluation of the three alternatives compared to the No Action Alternative. Recommendations and feedback from the LORSS PDT were considered. Since none of the initial three alternatives did well in meeting the planning objectives, the LORSS PDT re-evaluated the initial alternatives in an effort to develop additional alternatives that would better address planning objectives. From this effort evolved eleven alternatives, all of which were variations of Alternatives 1, 2 or 3. For further information on the development and refinement of the alternatives, refer to Appendix E. Using the performance measure results generated by the SFWMM, the PDT was able to screen the number of alternatives from eleven to five. The subsequent array of alternative plans resulting from the initial screening of the eleven alternatives is as follows:

1. Alternative 1aS2
2. Alternative 1bS2
3. Alternative 2A
4. Alternative 3
5. Alternative 4

During the initial alternative plan formulation effort, much attention was also centering on the ongoing rehabilitation efforts of the HHD. Additionally, the State's independent technical report on HHD was released early in 2006, which reiterated concerns with the structural stability of the HHD. Based on this information, and coupled with a 28 April 2006 letter from the Governor of Florida requesting that the Corps adopt a new regulation schedule to keep Lake Okeechobee at lower levels to protect the surrounding communities, a decision was made to include a maximum lake water level constraint measure for this study. A maximum lake water elevation of 17.25 ft. NGVD was incorporated into the study, and alternatives were formulated to prevent lake elevations exceeding 17.25 ft. NGVD, by maximizing releases from Lake Okeechobee to the estuaries above this stage level. The reason for selecting elevation 17.25 feet as the constraint elevation was to address the numerous factors that generate uncertainty in the rate of rise on the lake primarily during the rainy season. This elevation would be used as a protective buffer against Lake Okeechobee rising to an unacceptable high elevation which may compromise the integrity of the HHD. As a result of this constraint, along with a concurrent decision to include a base flow release zone in all alternatives, the PDT either modified the alternatives listed above, or eliminated them from further study because they were not able to meet the 17.25 feet maximum constraint. Two of the modified alternatives (Alternative 1bS2-A and Alternative 2A-B) were further modified to require zero days with Lake Okeechobee stages above 17.25 feet, resulting in the development of Alternative 1bS2-m and Alternative 2a-m. Through numerous modifications and adjustments of the alternatives to meet the constraint, and in consideration of other project objectives, the following final array of alternatives were carried forward for further analysis by the PDT:

1. Alternative 1bS2-A
2. Alternative 1bS2-m
3. Alternative 2A-B
4. Alternative 2A-m
5. Alternative 3-B
6. Alternative 4-A

It should be noted that Alternative 1aS2 was subsequently eliminated from further consideration during this time, since the modeled alternative could not provide maximum releases until reaching an elevation of 18.50 feet during a significant portion of the year. However, the concept and basic framework of Alternative 1aS2 was built into Alternative 1bS2, which was retained for further evaluation by the PDT. Alternative 1bS2 was similar to Alternative 1aS2, but performed much better at meeting the objective of achieving lower lake elevations.

The results of the alternative modeling were shared with the LORSS PDT and posted on the Corps' website (<http://hpm.sfrestore.org/loweb/sfwmm/>) for public viewing. The LORSS PDT evaluated the above alternatives using the performance measure results generated by the SFWMM including the new constraint of achieving zero or close-to-zero days above lake elevation 17.25 feet. Alternative 3-B was eliminated from further analysis, because it did not meet the objectives of the study. This was due to constraints in the current LORSS that did not exist back in 1999, which significantly reduced the performance of Alternative 3-B. In particular, the Storm-water Treatment Area (STA) 3/4 treatment capacity restriction for releases from Lake Okeechobee in the current LORSS created much higher lake elevations than previously modeled in 1999. The high lake elevations did not meet the objective of the study for achieving lower lake elevations. Upon completion of the performance measure evaluation against the No Action Alternative, the Corps solicited input from the PDT members, and selected Alternative 1bS2-m as the Preferred Alternative.

Selection of Preferred Alternative (1bS2-m)

Based on the evaluation of performance measures and other evaluation criteria, Alternative 1bS2-m was identified as the "Preferred Alternative" as presented in the August 2006 draft SEIS. Of all the alternatives, Alternative 1bS2-m was considered the best operational compromise for a new LORS because the alternative:

- produced the best balance of all objectives;
- allowed for quicker response to lake inflows;
- reduced the frequency of high lake stages ;
- improved optimum flow releases to the estuaries, including the addition of baseflow releases; and
- limited impacts to water supply, including greater Everglades.

Results of August 2006 Draft SEIS

Following release of the August 2006 draft SEIS for public and agency review and comment, the Corps held a series of public meetings to allow the public opportunities to express their views on the Preferred Alternative, 1bS2-m. Recommendations, feedback and comments from the public review process were considerable, with the majority of the comments focusing on performance of the Preferred Alternative with respect to reducing high volume flows to the Caloosahatchee Estuary. Comment letters received on the August 2006 draft SEIS can be found in Appendix H. Additionally, Appendix H includes a comment matrix that pulls out substantive comments from the letters, and the Corps response to those comments. Substantive comments on the Preferred Alternative addressed the following topics:

- What was the reason behind the 17.25 ft. high lake constraint
- Release more water south
- Increase STA and storage reservoirs
- Use available SFWMD lands for emergency lake water storage
- Water supply concerns
- Plan is acceptable at managing lake lower

- More equitable discharges to estuaries and WCA
- Concerns due to extreme high release from lake to the Caloosahatchee Estuary
- Release more low flows to reduce high flows
- Economic costs of high releases
- Account for wet weather cycle
- Limited discussion and coordination on endangered and/or threatened species such as manatee and sawfish

Based on consideration of public and agency comments, the Corps initiated further plan formulation and modeling in an attempt to address public comments, and improve the performance of the Preferred Alternative. It should be noted that many of the performance limitations of Alternative 1bS2-m observed in the modeling results revolved around the incorporation of the 17.25 feet high lake constraint. As modeled, Alternative 1bS2-m Lake Okeechobee water levels did not exceed 17.25 feet at any time during the period of record (POR) model simulation. During the development of additional alternatives, this 17.25 feet constraint was removed and treated as a performance measure, meaning that it would be acceptable for the Preferred Alternative to have some occurrences above the 17.25 feet elevation in the model simulation. The constraint was removed to allow the storage of additional water within Lake Okeechobee while simultaneously recognizing the need to provide for public health and safety under high lake level events. Consequently, the starting point for the formulation and evaluation of the new set of alternatives was not Alternative 1bS2-m, but the original alternative plan from which 1bS2-m was derived, referred to as Alternative 1bS2-A in the August 2006 draft SEIS. Alternative 1bS2-A allowed Lake Okeechobee to exceed 17.25 feet for 12 days during the POR as modeled.

Through a series of modifications to improve alternative performance (in particular to meet the objective of reducing high volume flows to the Caloosahatchee Estuary), three new alternatives were developed. All alternatives were then compared to the No Action Alternative based on evaluation of the performance measures. This resulted in a new Preferred Alternative regulation schedule (Alternative E), which is presented in this revised draft SEIS.

Modeling Updates and Need for Revised Draft SEIS

It is important to note that the updated modeling for the revised draft SEIS included the most current data sets and updated assumptions, as summarized in Appendix E. As a result of SFWMD rule-development, the updated modeling incorporated an alternative proposed water shortage plan (termed LOWSM-Lake Okeechobee Water Shortage Management Plan). Earlier alternative simulations in the August 2006 draft SEIS assumed a one-foot lowering of the current Water Shortage Trigger line (also referred to as the "existing SSM" line in the 2007 draft SEIS appendices) as a surrogate for the new Lake Okeechobee Water Shortage Management (LOWSM) plan that was under development by the SFWMD. The SFWMD subsequently provided more detail on LOWSM, as documented in Appendix G, Attachment 1.

Another important modeling change affects releases to the Lake Worth Lagoon. In the modeling efforts for the August 2006 draft SEIS, L-8 releases from Lake Okeechobee were routed through STA-1E, but STA-1E is not designed to treat L-8 local basin runoff or Lake Okeechobee discharges (associated with higher nutrient loads). The August 2006 draft SEIS No Action Alternative, i.e., base condition, and alternative modeling assumed treatment of L-8 local basin runoff and Lake Okeechobee discharges by STA-1E, resulting in additional volumes of water being passed through STA-1E, WCA-1, WCA-2 and into WCA-3A. Updated modeling for this SEIS assumes L-8 releases will be routed to tide (through S-155A) as they currently are and will not be routed through STA-1E.

Due to the updated modeling information and improvements to the 2006 Preferred Alternative that led to the formulation of new alternatives, it was necessary to disclose the environmental effects of these new alternatives and to describe alternative plan benefits and impacts in a revised draft SEIS, instead of finalizing the August 2006 draft SEIS. Most importantly, this revised draft SEIS incorporates the public comments and concerns of the August 2006 document.

2.3. UNCERTAINTY OF SFWMD WATER SHORTAGE MANAGEMENT RULES DURING PLAN FORMULATION

Concurrent with the Corps developing a revised LORS, the SFWMD was reviewing its water shortage rules in Chapters 40E-21 and 40E-22. The SFWMD water shortage rules provide the framework of when and to what extent low lake levels will trigger water use restrictions. Based on guidance from the SFWMD, the amendment of the existing water shortage rules is currently anticipated to be completed by the end of 2007, with proposed modifications implemented, in conjunction with any new regulation schedule resultant from LORSS.

Initially, based on guidance from SFWMD, modified Water Shortage Trigger (WST) assumptions were included during alternative formulation, modeling, and evaluations for the 2006 draft SEIS and 2007 revised draft SEIS. The No Action Alternative assumed the existing WST line, as has been traditionally used by the SFWMD, to be in place. All alternatives evaluated for the 2006 draft SEIS assumed a 1.0 feet lowering of the existing WST line as a surrogate for the anticipated rule changes by the SFWMD. During the plan formulation period of the 2007 revised draft SEIS, the SFWMD provided the Corps with their new proposed water shortage rules as described in the Lake Okeechobee Water Shortage Management (LOWSM) Plan (Appendix G, Attachment 1). The performance summary of the SFWMD draft LOWSM plan presented in Appendix G, Attachment 1, is shown compared to the 2006 draft SEIS Preferred Alternative, which represented the best available information for the LORSS during the early LOWSM development period. To ensure the 2007 revised draft SEIS alternatives were evaluated with the best available data for the proposed water shortage rules during plan formulation, the Corps incorporated the SFWMD draft LOWSM plan (Appendix G, Attachment 1) into the new round of modeling that supported the 2007 revised draft SEIS. Based on guidance from SFWMD during the 2007 revised draft SEIS plan formulation phase, the 2006 draft LOWSM plan was not

anticipated to undergo significant change prior to approval by the SFWMD Governing Board later in 2007.

During plan formulation, the Corps recognized that a level of uncertainty exists with the draft 2006 LOWSM plan used in evaluating the alternatives. However, alternatives were evaluated using the best available data for water supply planning, as provided by the SFWMD, at the time of alternative modeling and plan formulation. The 2006 draft LOWSM plan lowered the existing WST line by 0.80 feet, which was assumed a more likely scenario than either the current WST line or the 1-foot lowering surrogate previously assumed in the 2006 draft SEIS. The Corps recognized, during plan formulation, that if modifications were made to the 2006 draft LOWSM by the SFWMD, the modifications were not anticipated to result in adverse environmental effects, compared to the affects evaluated in the revised 2007 draft SEIS and were not expected to effect the comparison of alternatives. During plan formulation the Corps recognized SFWMD modifications to the 2006 draft LOWSM may change the anticipated water supply performance, compared to the impacts reported and evaluated for the LORSS alternatives in the 2007 LORSS revised draft SEIS.

The 2006 draft LOWSM plan represented a proposed modification to the existing Water Shortage Rule (also referred to as “existing WST [Water Shortage Trigger]”) used by the SFWMD, in place since 2001. The Water Shortage Rule is sometimes also referred to as “existing SSM” (Supply-Side Management), but there is a difference between the “SSM” and “WST” terms such that the terms are not technically interchangeable. The original SSM Plan, which is described in the SFWMD 1991 SSM “Yellow Book,” was implemented during the 1989-1990 drought. Problems during the 2000-2001 drought prompted a decision by the SFWMD to change the plan that resulted in the existing WST rules. Although technically a misnomer, references within this report and appendices to the “existing SSM” line or rules refer to the existing WST line and rules that have been in place since 2001. All SFWMM simulations completed for the 2007 draft SEIS include either the existing WST operations or the 2006 draft LOWSM plan; the original SSM Plan (1991 Yellow Book) is not the current water shortage plan used by the SFWMD, and the original 1991 SSM Plan has not been utilized for the LORS Study.

Table 2-1 provides a summary of Lake Okeechobee Water Shortage Management Plans which had, as of the 2007 revised draft SEIS, been implemented or proposed by the SFWMD and included as assumptions in the LORS alternative evaluations, including key differences in the allocation computation methodology and maximum cutback determination.

TABLE 2-1: SUMMARY COMPARISON OF WATER SUPPLY PERFORMANCE

Plan Name	Trigger Line Extreme Stages¹	Allocation Computation Methodology²	Maximum Cutback Determination	Comments
SSM/Prior 2002	13.5 to 11 ft	As described in "Yellow Book" (A. Hall, 1991). Supply Side Management Method was used to calculate weekly allocation during water shortage for LOSA based on available volume in Lake above "reference elevation" (11.0 ft)	Straight number: Varied on date relative to June 1 and stage of Lake above the reference elevation. The maximum cutback would not exceed 67%.	Old SSM. Implemented in the 1989-1990 drought. Problems during 2000-2001 drought prompted decision to change plan. Used in several SFWMD simulations prior to the LECRWSP - 2000
SSM/2002-present	13 to 10.5 ft (District rule 40E-22.332 F.A.C.)	As described in "Yellow Book" (A. Hall, 1991) with a reference stage of 10.5 ft, but with cutbacks defined by Phase of restrictions per District water shortage rule: Phase I – 1.5% cutback Phase II – 30% cutback Phase III – 45% cutback Phase IV – 60% cutback	Phased approach (1-4) based on forecast Lake stage on June 1st: 1.5%, 30% if above or at 10.5 ft; 45%, 60% if below 10.5 ft - Phase I if June 1st Lake stage above 10.5 ft - Phase II if June 1st Lake stage at 10.5 ft - Phase III if June 1st Lake stage below 10.5 ft. District staff will identify a revised reference elevation based on factors in District Rule - Phase IV established by District's Governing Board	This is based on the Existing Water Shortage Rule (Sometimes called also Existing SSM). This approach has been extensively simulated using SFWMD since 2003. Referred to as the "existing WST" (Water Supply Trigger) method. This approach was used to evaluate water supply cutbacks for both 'LORSM' and 'TSP3 with existing WST'
LOWSM	12.2 to 9.7 ft	Based on 1 in 10 LOSA demand, processed from previous SFWMD simulations	Phased approach (1-4) based on preset set of rules for 15, 30, 45 and 60%. Proposed cutback: adjusted to keep water supply to LOSA same or better than VSE. Note that SFWMD proposed environmental enhancements in LEC Water Supply plan to address MFL exceedances that were identified to occur with TSP.	District initiated rule development (Feb 2006) to change existing water shortage rule to reflect 1-in-10 LOSA demands and phased-cutback approach. Proposed LOWSM (Sept. 2006) designed to equal or exceed water supply performance as shown in July 2006 version of TSP. Environmental interest object as the proposed LOWSM schedule was not consistent with existing rules for minimum flows and levels for Lake Okeechobee.

¹ Trigger line: Calendar based line advising when the Lake stage is low enough to start considering the imposition of water restrictions.

² Determination of the lake Okeechobee allocation: The initially determined amount of water that will be released from the Lake in order to meet Water supply needs in LOSA

³ Lower East Coast Regional Water Supply Plan, (May 2000)

The SFWMD 2006 refined LOWSM plan was presented in a series of workshops in the fall of 2006 and spring of 2007, parallel with the USACE efforts to complete the LORSS 2007 revised draft SEIS. Concerns from environmental groups regarding this proposal and compatibility with the Lake's minimum flow and level rule criteria were identified. Specifically, it was noted that it was possible under the LOWSM plan that the Lake Okeechobee minimum flow and level rule (MFL) criteria would be exceeded without water restrictions being imposed. Such a situation was contrary to SFWMD rules and identified as unacceptable without additional efforts to review the Lake Okeechobee MFL criteria; the SFWMD suspended rule making on the 2006 LOWSM plan in May 2007 and informed the USACE that the SFWMD may not be able to revise the 2006 LOWSM trigger line below the current SSM trigger.

In May 2007, the USACE was preparing to release the LORSS revised draft SEIS for public review and comment. In response to the SFWMD suspension of the LOWSM rule making process, the USACE conducted modeling analysis to quantify the potential effect on water supply performance if no change to the existing SSM trigger line was made. The range of potential water supply performance between the existing SSM trigger line and the SFWMD refined LOWSM plan (assumed in place for Alternative A through E presented and evaluated in this report) was bracketed and included in USACE water supply performance evaluation of this LORSS revised draft SEIS. A comparison of the simulated water supply performance for the No Action Alternative, the Preferred Alternative with LOWSM, and the Preferred Alternative with Existing Water Shortage Triggers (WST) is provided in Section 6.12.1. The Preferred Alternative with existing WST simulation provides information on the implications if the SFWMD implements water shortage restrictions under its current rules (assumes no changes to the current SFWMD Water Shortage Plan in response to the LORSS proposed modifications to the LORS).

Following plan formulation and alternative modeling, coincident with the release of the LORSS 2007 revised draft SEIS, the Lake Okeechobee Service Area (LOSA) was being subjected to water shortage restrictions as the stage of the Lake fell within the Zone A water shortage area as described in SFWMD Rule (40E-22, 40E-21 F.A.C.). Working with the Governing Board and stakeholders, the SFWMD imposed water shortage cutbacks consistent with the 2001 rule but based on crop demands as they occur during a 1 in 10 level drought (as opposed to average rainfall assumed conditions) and consistent with the SFWMD's MFL criteria. The SFWMD held its last scheduled rule workshop in late summer, 2007. This workshop introduced a rule concept which reflected management of the Lake during the 2007 drought and was consistent with the 2001 version of the rule and the Lake's MFL criteria. The water shortage rule imposes more significant water restrictions earlier on through LOSA (compared to the existing water shortage management plan established in 2001). This proposal was supported by stakeholders and was presented to the SFWMD Governing Board for authority to publish the rule and adopt the rule, if no public hearing was requested. Because no hearing was requested by October 19, 2007 the "modified LOWSM" rule is expected to be effective November 15, 2007. SFWMD's Notice of

Proposed Rule for Lake Okeechobee Water Shortage is provided as Attachment 2 of this appendix.

Though operational details for implementation have not been provided to the USACE in time for publication in the LORS Final SEIS, the water shortage rule is expected to provide water supply performance within the bracketed range that was evaluated in the LORSS revised draft (June 2007) SEIS. Water supply performance is expected to fall closer to the evaluation provided for the existing water shortage rules than to the performance with the refined LOWSM. The Water Control Plan will be finalized with effects within the bracketed range for water supply performance documented in this SEIS. Changes to the Water Control Plan to reflect any modifications by the SFWMD to its water shortage management rules can be accommodated under this analysis so long as the SFWMD can demonstrate they do not result in impacts outside the bracketed performance range.

2.4. FEATURES OF ALTERNATIVES EVALUATED IN THIS STUDY

Some of the options considered when formulating the alternatives evaluated in this study were:

- 1) Lower the stage lines defining the operational zones to minimize impact to the HHD;
- 2) Provide a base flow to one or both of the estuaries to minimize the occurrence of high volume releases to the estuaries;
- 3) Include a maximum limit of the lake regulatory releases passed through STA-3/4, based on assumed treatment capacity given the current nutrient levels within Lake Okeechobee;
- 4) Use different types of data to measure tributary hydrologic condition (THC), such as drought indicators and total Lake Okeechobee net inflow (LONIN);
- 5) Operate within optimal Lake stage envelopes;
- 6) Provide lake operators with as much flexibility as possible to lower the lake stages when needed to achieve project objectives.

2.5. COMMONALITIES OF ALTERNATIVES

Section 2.6 describes both in text and graphically, the proposed alternative water regulation schedules described as Alternatives A through E. The No Action Alternative, which is the baseline against which all the alternatives were compared is included as well as a description of features common to the alternatives analyzed.

All of the alternatives analyzed in the SEIS included the WSE decision tree framework, and were designed to increase operational flexibility. Considering the potential benefits from recent lake inflow forecasting tools, and the rapid increase in state-of-the-art forecasting technology, it is practical to establish more flexible rules which allow lake managers to utilize supplemental information and apply their best professional judgement in making operational decisions.

All of the alternatives modeled assumed STA-3/4 treatment capacity restriction for releases. STA-3/4 is designed to improve the quality of Lake Okeechobee water, by

reducing phosphorus loads, prior to discharging to WCA 2A and 3A. The assumed treatment capacity restriction for STA-3/4 is simulated in the SFWMM by restricting the wet and dry season conveyance capacities for the Miami and North New River canals to pass approximately 58,500 acre-feet, average annual during the dry season and 4,700 acre-feet average annual during the wet season from Lake Okeechobee to the STA-3/4; the average annual treatment capacity constraint is assumed to be approximately 63,200 acre-feet. STA-3/4 is one of six large treatment wetlands managed by the SFWMD as part of the Everglades Construction Project. STA-3/4 was designed to capture stormwater runoff from the basins adjacent to the North New River and Miami canals as well as to capture and treat regulatory releases from Lake Okeechobee. STA-3/4 is located immediately east (and north) of the Holey Land Wildlife Management Area (WMA) north of WCA 3A and west of Highway U.S. 27.

All alternatives modeled and evaluated, with the exception of the No Action Alternative, assume the LOWSM water shortage rules (Appendix G, Attachment 1). The No Action Alternative assumes the existing Water Shortage Trigger (WST) line, as set by the SFWMD, to be in place. Another feature of the LOWSM, included in the alternative modeling and evaluation of all alternatives (including the No Action Alternative), is the incorporation of temporary forward pumps. The SFWMD installed and operated temporary forward pumps in 2007, which allowed water managers the ability to discharge water from Lake Okeechobee during periods of extremely low water levels, when the standard gravity-feed structures would no longer deliver water to users within the EAA and the Lower East Coast. Based on operational guidance from the SFWMD, the pumps are simulated to trigger on for water supply demands if the lake stage falls below 10.2 feet; while the pumps are assumed turned off when the lake stage recovers to 11.2 feet. Based on guidance from the SFWMD, the water supply temporary forward pump design capacities are assumed as 400 cubic feet per second (cfs) at S-354, 600 cfs at S-351, and 400 cfs at S-352. A Department of Army permit was issued in 2007 for installation and operation of the temporary forward pumps.

2.6. DESCRIPTION OF ALTERNATIVES

Each alternative is a variation of operational rules to determine when, where, and how much water will be released from the lake to downstream systems. The best way to display this information is to use charts and decisions trees for each alternative schedule developed. **NOTE: The modeling nomenclature is captured in parenthesis after the alternative name. This should be helpful when referring to the modeling Appendix, E. Additionally, some of the appendices, in particular A, D and E, refer to the Preferred Alternative as the “TSP” (Tentatively Selected Plan). These terms are used interchangeably. References within this report and appendices to the “existing SSM” line or rules refer to the existing Water Shortage Trigger (WST) line and rules, although the terms are not generally used interchangeably in practice.**

2.6.1. NO ACTION ALTERNATIVE

The No Action Alternative is the baseline for the alternative analysis. Under No Action, environmental consequences will still occur because the existing environment is not

static. Under No Action, the Corps would continue to manage Lake Okeechobee under the current regulation schedule, WSE, which includes the temporary planned deviation referred to as the CLA approved in 2005. In addition, the No Action Alternative includes operation of the temporary forward pumps, which were permitted, installed and operated by the SFWMD, in 2007. The No Action Alternative assumes the existing WST line, as set by the SFWMD, to be in place.

To better understand the No Action Alternative, the current regulation schedule, WSE, must be briefly described. The WSE schedule, approved in July 2000, introduced new elements in the operational decision making process.

One of the elements unique to the WSE schedule is the traditional calendar-based schedule, delineating the different operational zones, as shown in Figure 2-1. Figure 2-1 shows Zones A through E and the table of recommended releases. Zones A through D are regulatory release zones designated for flood control (USACE, 2000). Zone E is referred to as the water supply zone, since regulatory releases cease, and water supply needs are considered. A key feature of the WSE schedule is the lower operational zone labeled Zone D. This zone allows more operational flexibility to deliver water south at lower lake water levels. Zone D also has a key feature for estuary releases. Zone D is divided into three sub-zones, referred to as Level I, II and III. Within these sub-zones, pulse releases of different intensities are made to the Caloosahatchee and St. Lucie estuaries. The higher the level of pulse, the more flows and higher volume of water is delivered to the estuaries.

Another element unique to the WSE schedule is the use of decision trees to guide releases south to the WCAs, and east and west to the estuaries. The decision trees are shown in Figure 2-2 and Figure 2-3. Hydrologic outlooks (forecasts) play an important role in the decision trees. Data are collected weekly to assist managers in navigating the decision trees.

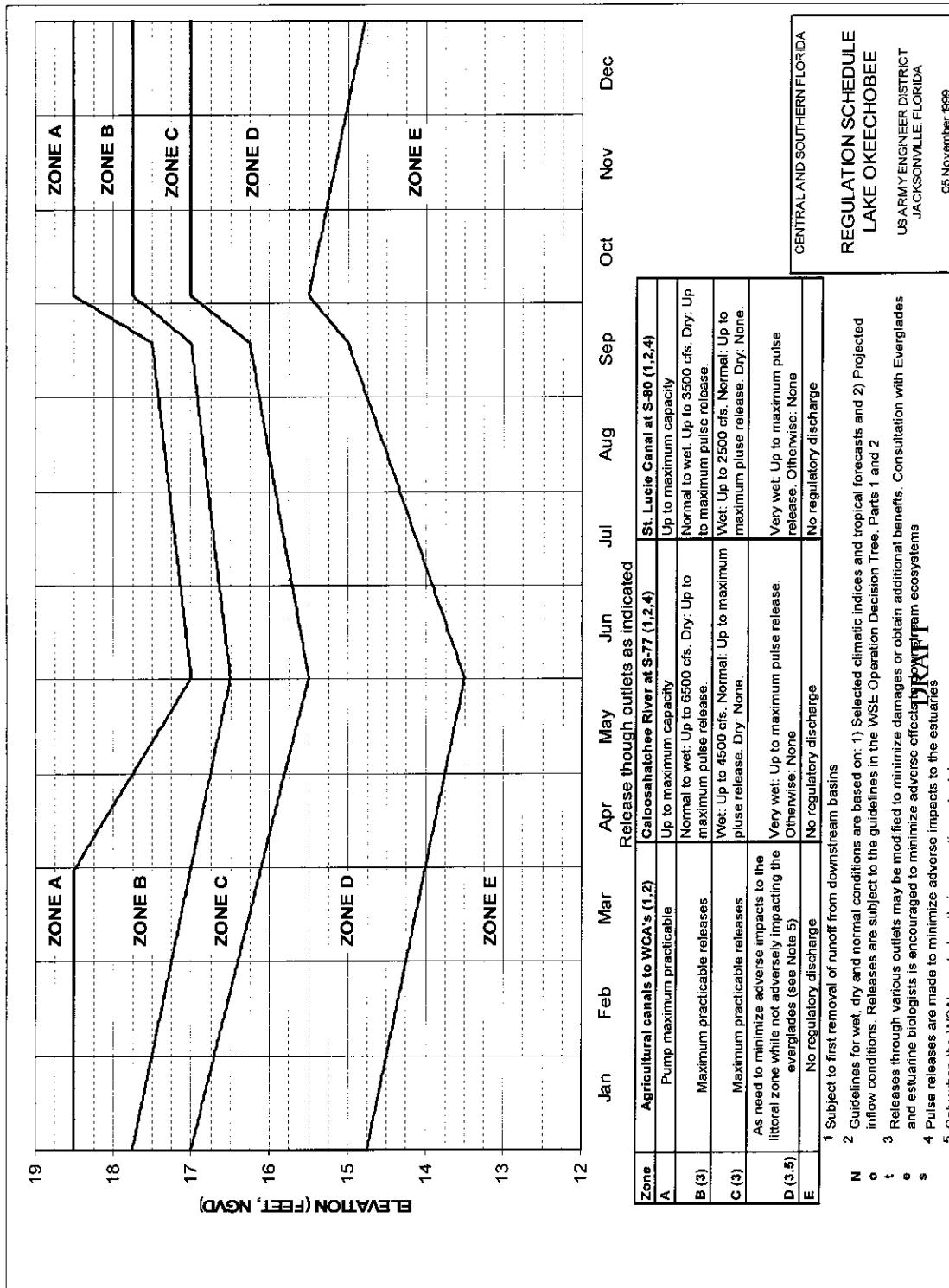


Figure 1

FIGURE 2-1: CURRENT LAKE OKEECHOBEE REGULATION SCHEDULE: WSE

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WSE Operational Guidelines Decision Tree

Part 1: Define Lake Okeechobee Discharges to the Water Conservation Areas

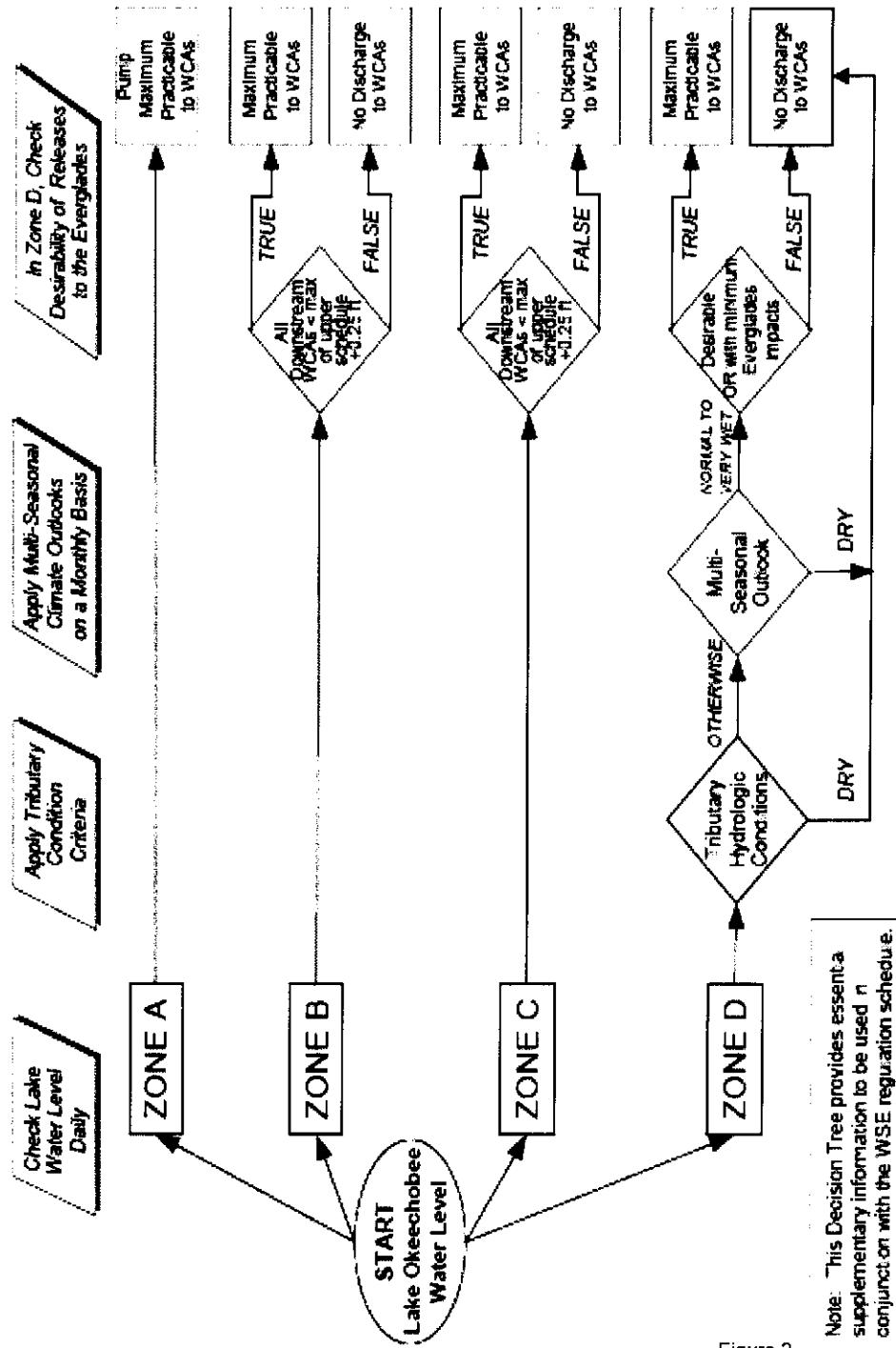


Figure 2

FIGURE 2-2: CURRENT LAKE OKEECHOBEE REGULATION SCHEDULE: WSE

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WSE Operational Guidelines Decision Tree

Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)

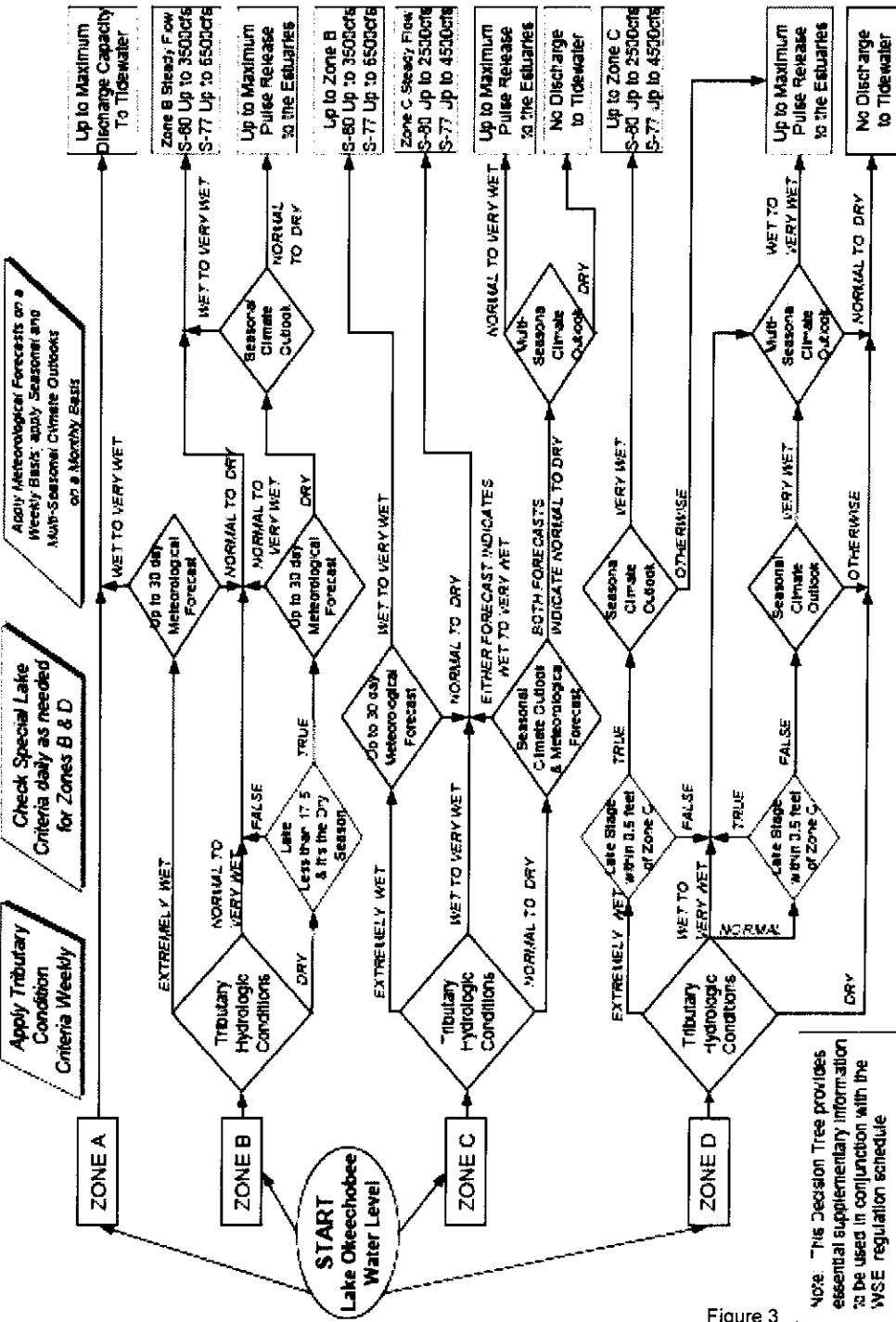


Figure 3

FIGURE 2-3: CURRENT LAKE OKEECHOBEE REGULATION SCHEDULE: WSE

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2.6.2. ALTERNATIVE A (IBS2-A)

Alternative A was developed from the current WSE decision tree, i.e. Operational Guidance, structure. The regulation schedule and Operational Guidance for Lake Okeechobee discharges to the WCAs and discharges to tidewater for Alternative A are shown in Figure 2-4, Figure 2-5, and Figure 2-6, respectively. Operational experience under WSE and the availability of additional climatological data led to the following recommended modifications to WSE for this alternative:

1. Regulation schedule lines for Zone A, Zone B, and Zone C are lowered. If the stage of Lake Okeechobee exceeds 17.25 ft., NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater. The lowering of the upper regulatory zones results in a regulation schedule that is more pro-active to limit potential high water conditions within Lake Okeechobee.
2. THC are applied that represent longer-term wet or dry conditions that have persisted in the tributaries. Updated THC indicators enable the proposed regulation schedule to avoid frequent breaks in the regulatory outflows that may occur due to shorter dry periods. The Palmer Drought Index (PDSI) is proposed to replace the 30-day net rainfall, and the 14-day mean LONIN is proposed to replace the 14-day mean S-65E flow. The classification bands for the PDSI and LONIN THC indicators are summarized in Table 2-1.
3. The line representing the divide between Zone D and Zone E is reshaped: the bottom of Zone D is flattened during the periods in which the estuary ecological systems may be more impacted by large freshwater discharges, especially in late winter, early spring, and during the October through November period. The modified regulatory line promotes a quicker response in the autumn and winter months to large inflows that often are generated during the hurricane season.
4. A new base flow zone (Zone D0) is established below the bottom of the re-shaped Zone D. Base flow is allowed when Lake Okeechobee water levels are in Zone D0 or above (Zone C decision tree outcome for dry THC, seasonal, and multi-seasonal forecasts is base flow), but no base flow releases are called for when the stage falls below the bottom of Zone D (Zone D0). During the alternative formulation process, data and recommendations were evaluated and the recommended base flow release was determined to be 450 cfs to the Caloosahatchee Estuary (measured at S-79) and zero base flow to the St. Lucie Estuary. Risks to the water supply performance objective are anticipated to be minimized with the forward pumps assumed in place to allow for water supply at lower Lake water levels. The bottom of the base flow zone ranges from 11.5 ft. NGVD on May 31 to 13.0 ft., NGVD during October and November. For Figure 2-5 (discharges to WCAs), releases to the WCAs when in Zone D0 adhere to the same decision tree as the remainder of Zone D;

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for Figure 2-6 (discharges to tidewater), releases when in Zone D0 will be base flow, and the decision tree of Zone D is not applicable.

THC and seasonal climate forecasts are updated to allow increased operational flexibility in managing lake stages, and specifically to avoid extreme high lake stages. A significant number of decision tree outcomes for THC and seasonal forecast are updated to allow the quicker release of lake water, as compared to WSE (for example, “Extremely wet” THC is changed to “very wet” or “wet to very wet” is changed to “normal to wet”). The additional inclusion of lake stages forecasted to rise into Zones A or B also introduces additional operator flexibility by allowing for utilization of all available hydrologic and meteorological forecasting data. The changes to WSE for Alternative 1bS2 are indicated by the red font in Figure 2-6.

5. Moderate to extreme high discharges to the St. Lucie Estuary are reduced by modifying the maximum discharge rates for Zone B and Zone C from 3500 to 2800 cfs and 2500 to 1800 cfs, respectively.

/OKEECHOBEE/ZONE A/ELEV-REG/01JAN1960/IR-DECADE/ALT1BS2-A17.25/

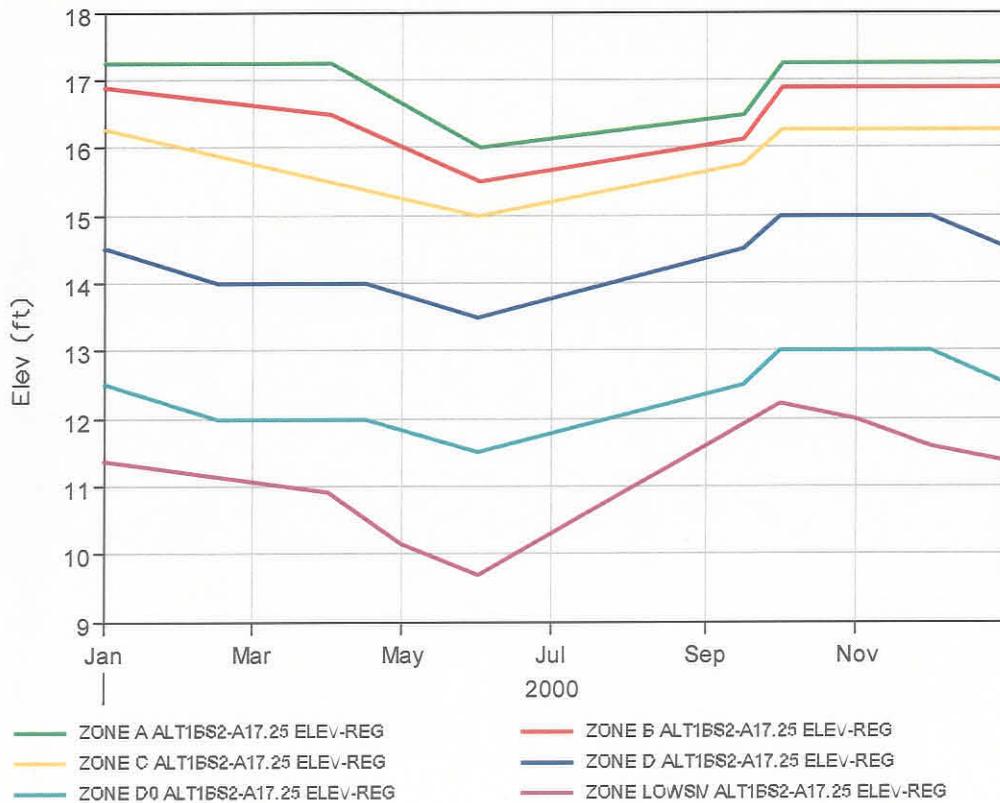


FIGURE 2-4: REGULATION SCHEDULE FOR ALTERNATIVE A

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Lake Okeechobee Operational Guidance

Part D: Establish Allowable Lake Okeechobee Releases to the Water Conservation Areas

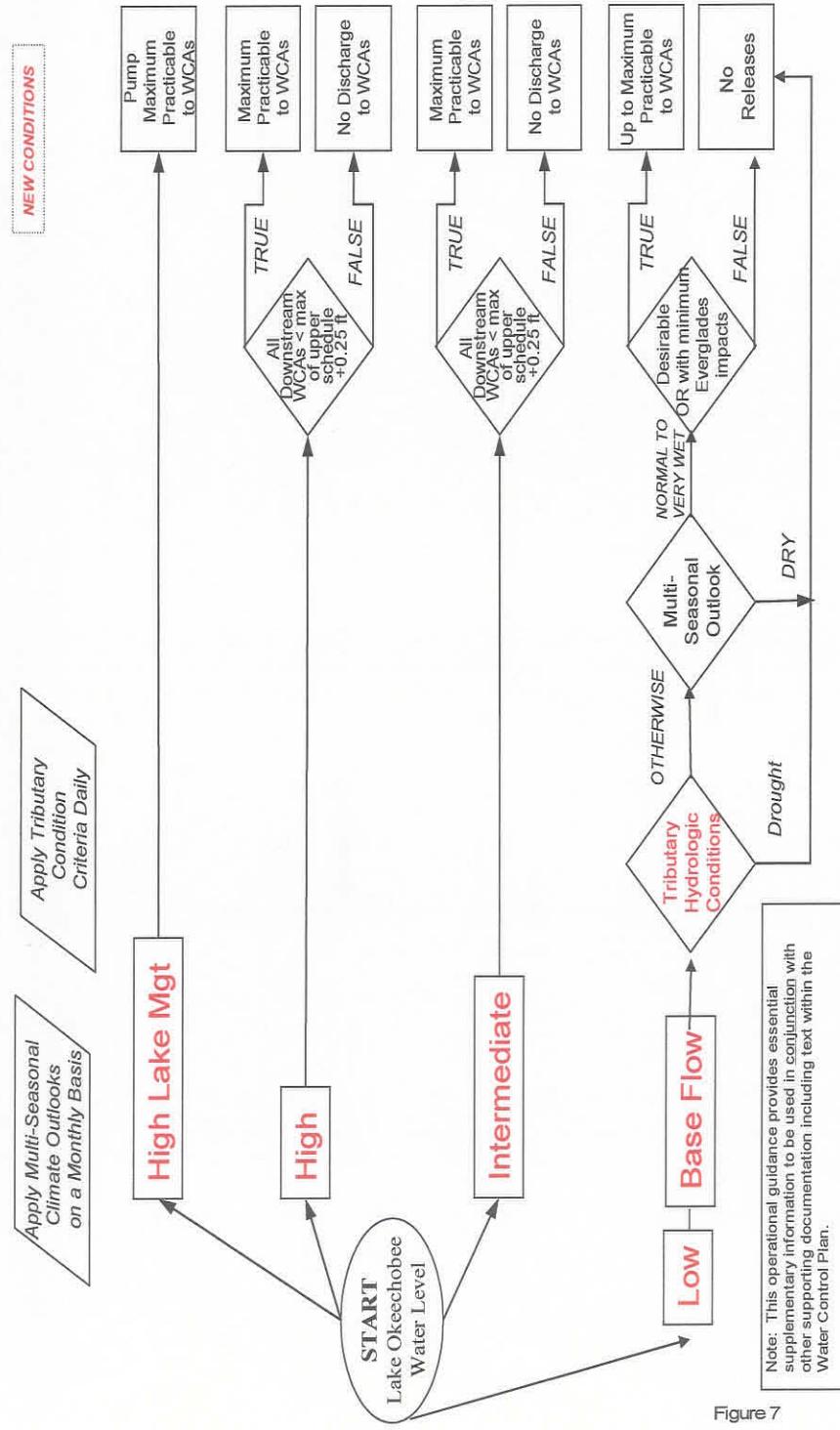


Figure 7

**FIGURE 2-5: OPERATIONAL GUIDANCE, PART 1 FOR ALTERNATIVE A, ALTERNATIVE B, ALTERNATIVE C,
ALTERNATIVE D, AND ALTERNATIVE E**

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WSE Operational Guidelines Decision Tree

Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)

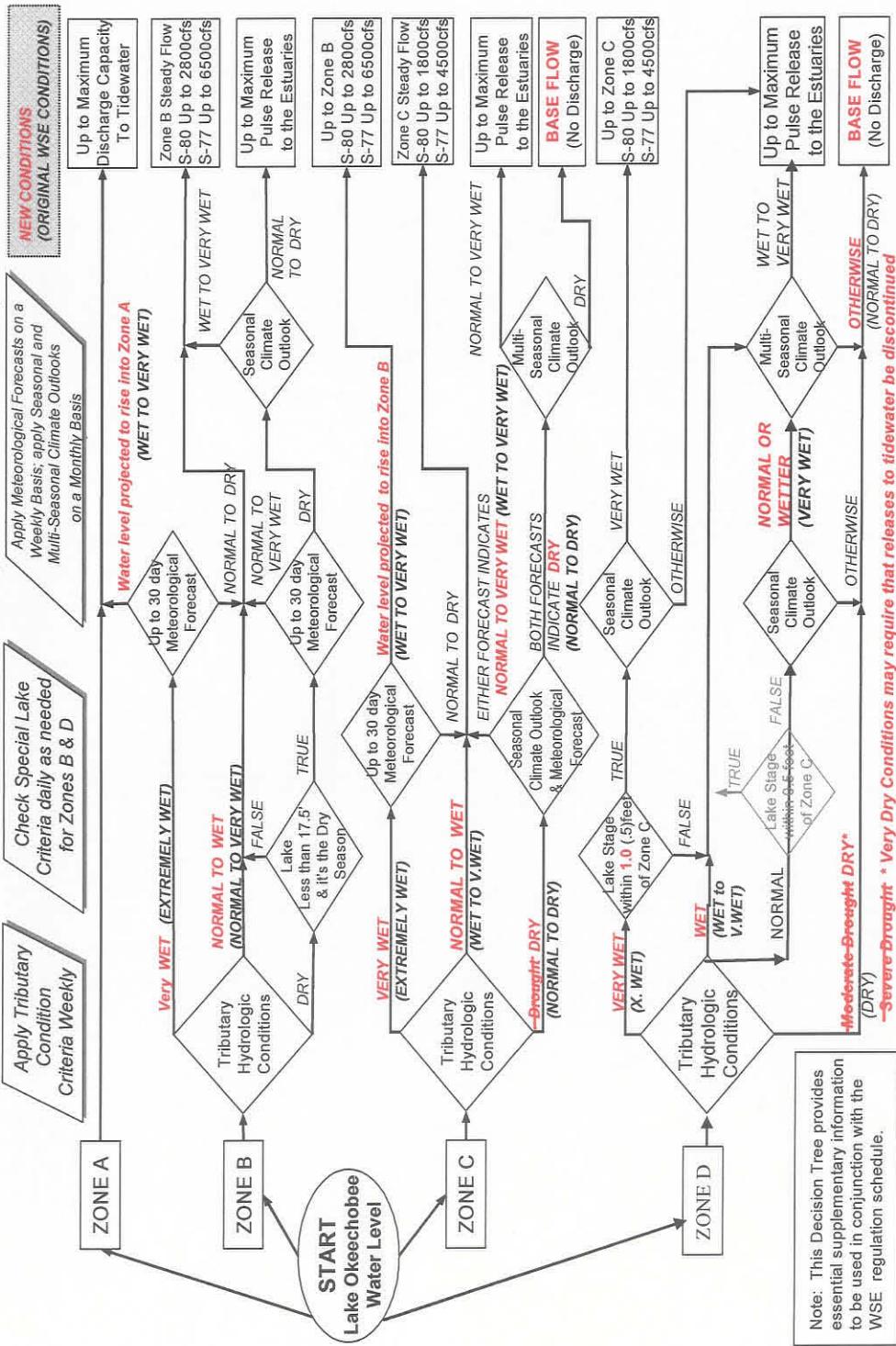


FIGURE 2-6: OPERATIONAL GUIDANCE, PART 2 FOR ALTERNATIVE A AND ALTERNATIVE B

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2.6.3. ALTERNATIVE B (1BS2-M)

Alternative B is the Preferred Alternative (1BS2-m) in the August 2006 draft SEIS. Alternative B is similar to Alternative A, but with lowering of the second and third regulatory release lines and a lowering of the top three regulatory release lines during the late hurricane season from September 15 through November 1. Alternative A simulation output (SFWMM model) showed the 17.25 feet stage criteria for Lake Okeechobee extreme high water to be exceeded for 12 days during the 36-year simulation period-of-record (POR). Alternative A was modified to remove any simulated daily stage in excess of 17.25 feet within Lake Okeechobee for safety issues with the HHD. Modifications to Alternative A to create Alternative B are summarized below:

1. Regulation Zones A, B, and C are lowered during the late hurricane season (September 30 stage breakpoints are changed to November 1)
2. Regulation lines for the bottom of Zones B and C were lowered. Zone B breakpoints were first lowered to be mid-way between the bottom of Zone A and the bottom of Zone C. The bottom of Zone B was then lowered by an additional 0.15 feet and the bottom of Zone C was lowered by 0.10 feet, as required to achieve zero days with lake stage greater than 17.25 feet elevation. The simulated peak stage for Lake Okeechobee is 17.23 feet, during October 1995. The regulation schedule for Alternative B is shown in Figure 2-7; the Operational Guidance remains unchanged from Alternative A (Figure 2-5 and Figure 2-6).

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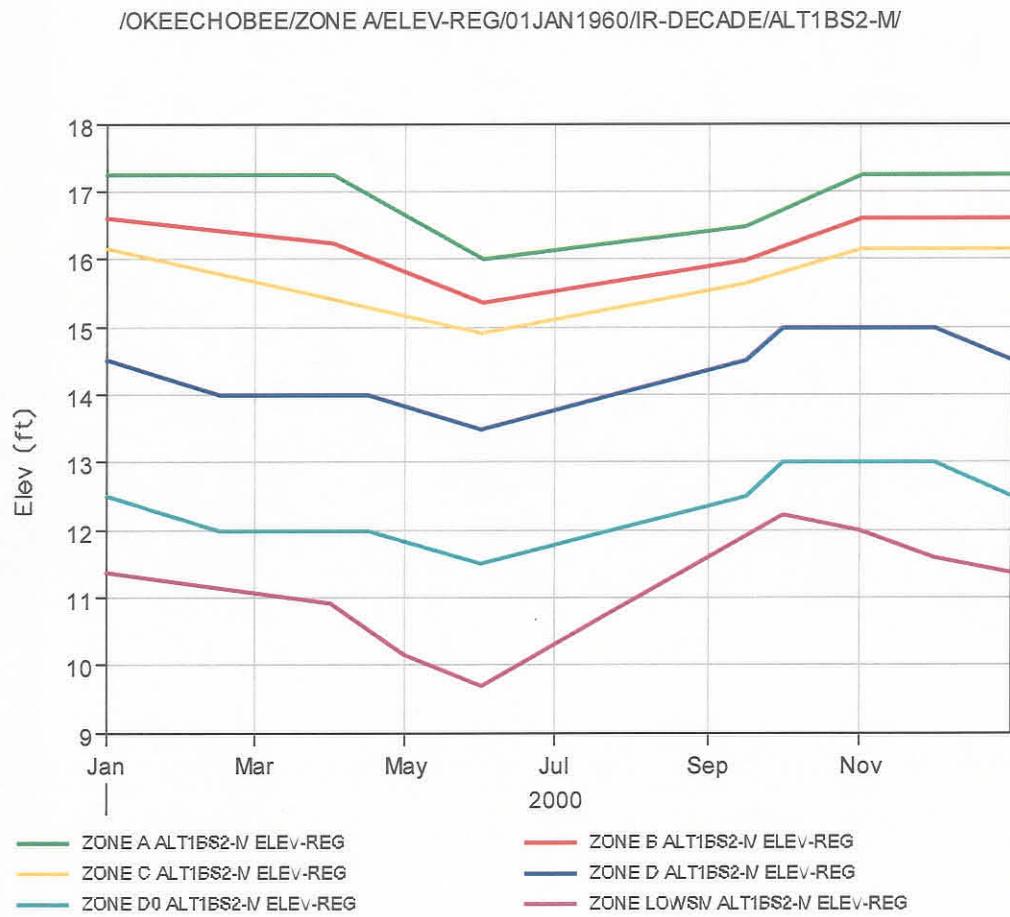


FIGURE 2-7: REGULATION SCHEDULE FOR ALTERNATIVE B

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2.6.4. ALTERNATIVE C (T1)

Alternative C is a modification of Alternative A. The Regulation Schedule for Alternative C is shown in Figure 2-8. The Operational Guidance, Part 1 (releases to WCAs) for Alternative C remains unchanged from Alternative A, and the Operational Guidance with updated terminology is shown in Figure 2-5. The Operational Guidance, Part 2 for regulation schedule for Alternative C is shown in Figure 2-9. The following changes were made to Alternative C:

1. Lake Okeechobee late season break points are changed from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address the potential of late season hurricanes.
2. Level 3 pulse measured at S-77 is changed from average daily flow of 3000 cfs to 2800 cfs.
3. A base flow of 350 cfs to the St. Lucie Estuary measured at S-80 in low and intermediate bands is included in this alternative.
4. Base flow to the Caloosahatchee Estuary is changed from up to 450 at S-79 to up to 650 cfs measured at S-77 in the low and intermediate bands. It is recognized that discharge at S-79 of up to 800 cfs could be recommended for occasional implementation, but this infrequent recommendation would not be consistent with inclusion for the complete POR modeling; additional flow at S-79 could be delivered by redistribution of the baseflow releases to the St. Lucie Estuary.
5. No changes to base flow of 450 cfs measured at S-79 in the base flow band.
6. The bottom of the base flow band is raised by 0.25 feet.
7. Change the High and Intermediate band flow of up to 2800 cfs measured at S-80 back to WSE level of up to 3500 cfs.

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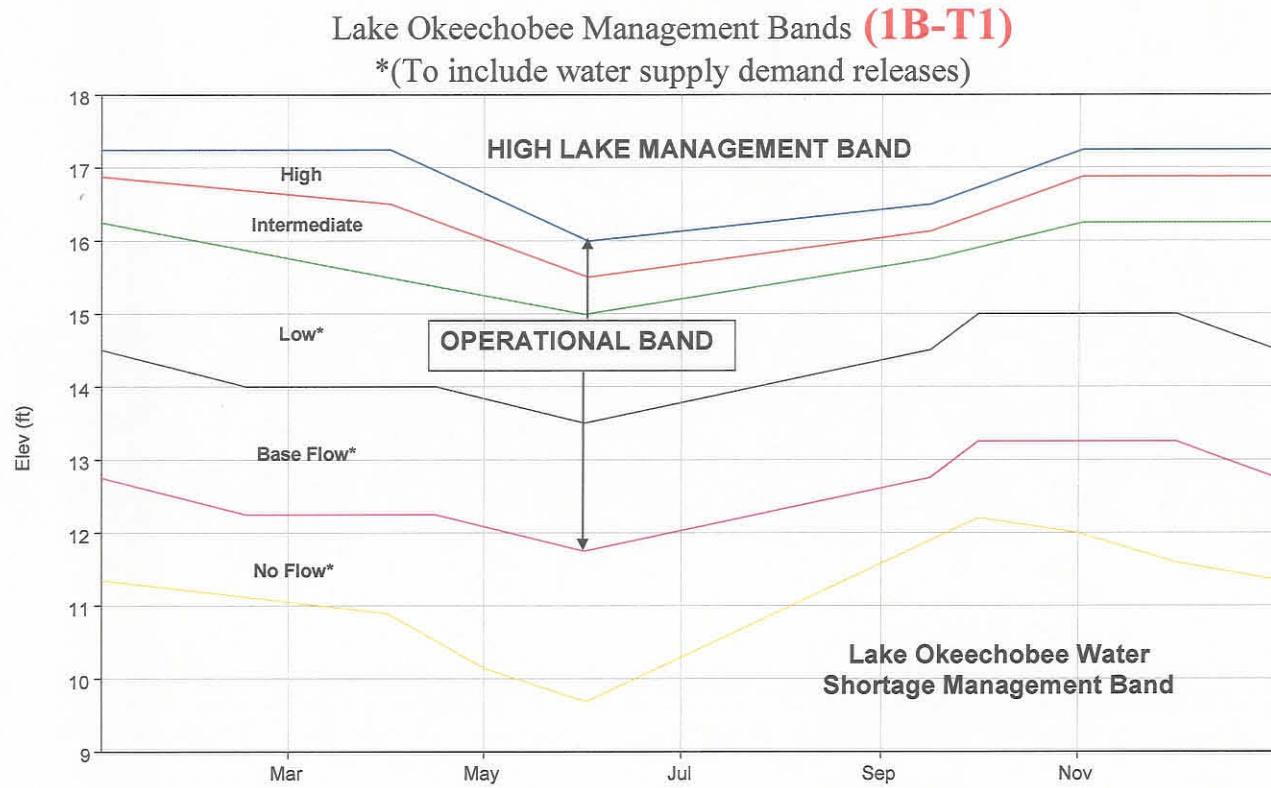


FIGURE 2-8: REGULATION SCHEDULE FOR ALTERNATIVE C

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Lake Okeechobee Operational Guidance (1B-T1)

Part 2: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)

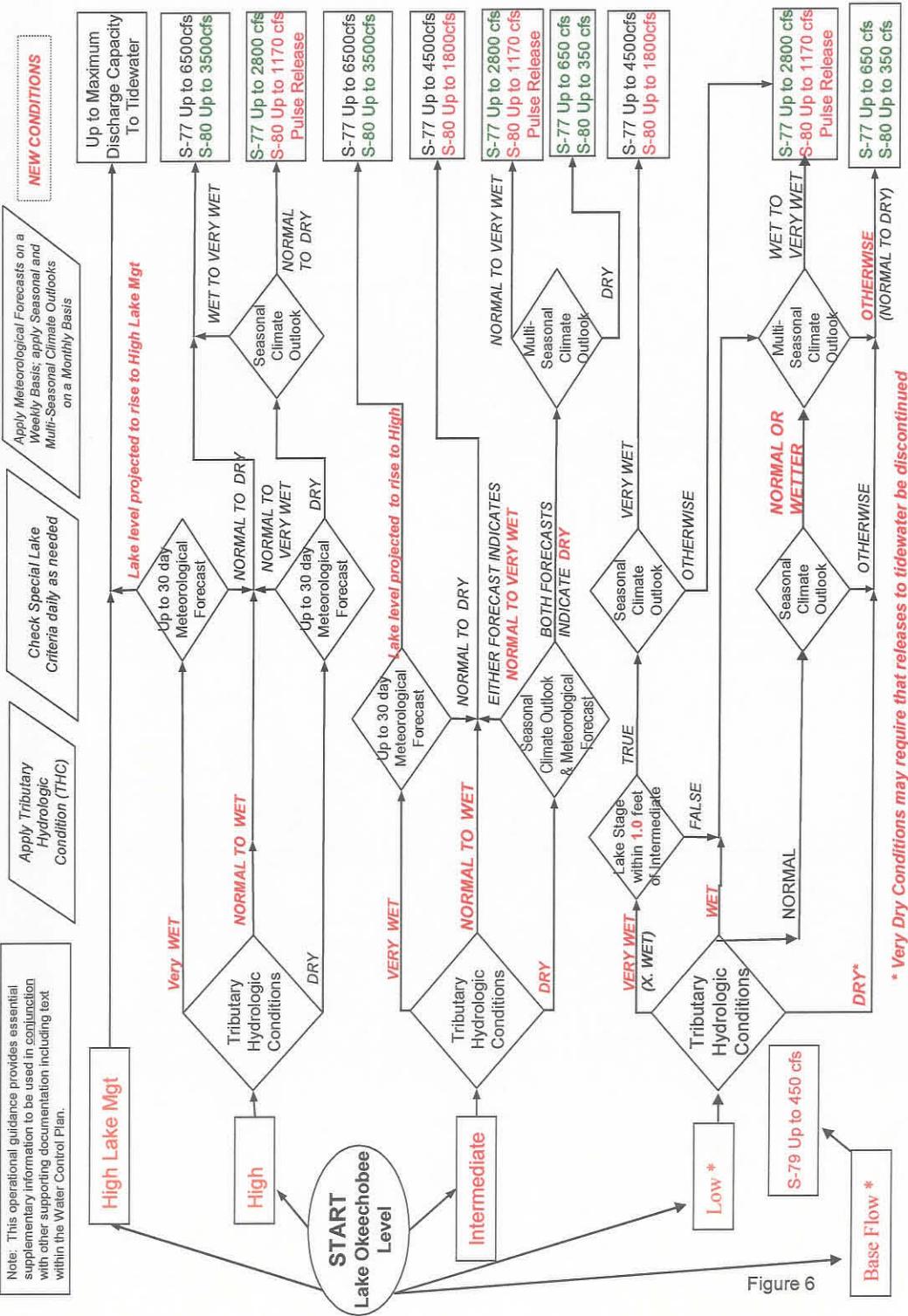


FIGURE 2-9: OPERATIONAL GUIDANCE, PART 2 FOR ALTERNATIVE C

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2.6.5. ALTERNATIVE D (T2)

Alternative D is a modification of Alternative A, and was proposed by the SFWMD based on screening results from the Lake Okeechobee Operations Screening Model (LOOPs). The Operational Guidance, Part 1 (releases to WCAs) for Alternative D remains unchanged from Alternative A, and the Operational Guidance with updated terminology is shown in Figure 2-5. Figure 2-11 shows the Part 2 Operational Guidance. Figure 2-10 shows the regulation schedule for Alternative D. The following changes were made to Alternative A, to develop Alternative D:

1. Zone D0 raised to 12.6 feet to maintain Zone D0 higher than navigation minimum Lake Okeechobee elevation of 12.56 feet.
2. All Caloosahatchee Estuary pulse releases measured at S79 instead of S77, in all lake bands when pulse releases are called for, to reduce high flow exceedences caused by lake release plus local C-43 basin runoff.
3. Bottom of Zone D1 lowered by one half foot, to encourage more pulse releases which help reduce steady higher volume discharges.
4. Add a small baseflow of 200 cfs (low volume discharge) to St. Lucie Estuary (below S-80, to include accounting of C-23 and C-24 basin inflows) whenever base flow releases are called for in decision tree. Additional base flow deliveries at S-79 (450 cfs at S-79 is included, per Alternative A) could be delivered by redistribution of the baseflow releases to the St. Lucie Estuary.

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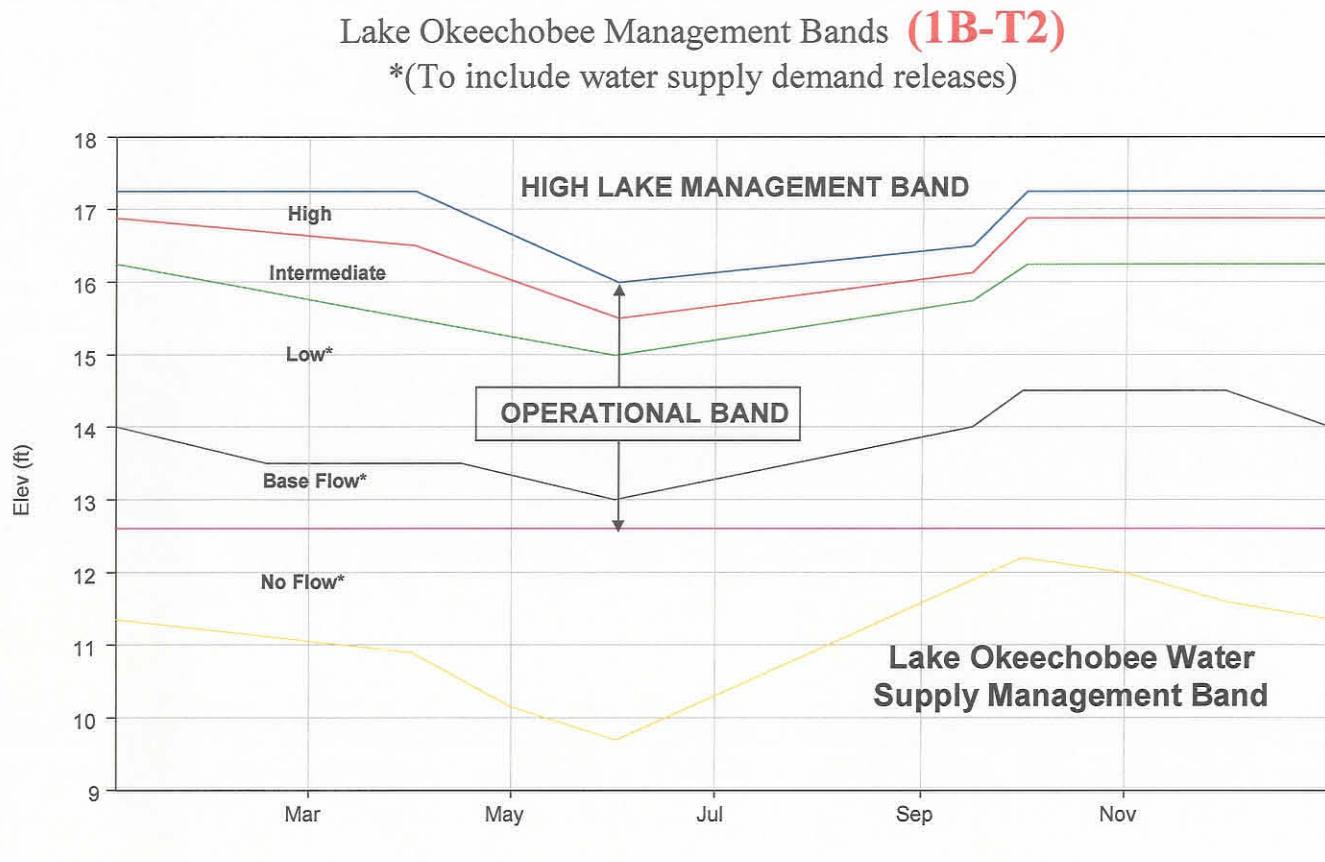


FIGURE 2-10: REGULATION SCHEDULE FOR ALTERNATIVE D

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Lake Okeechobee Operational Guidance (1B-T2)

Part 2: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)

Note: This operational guidance provides essential supplementary information to be used in conjunction with other supporting documentation including text within the Water Control Plan.

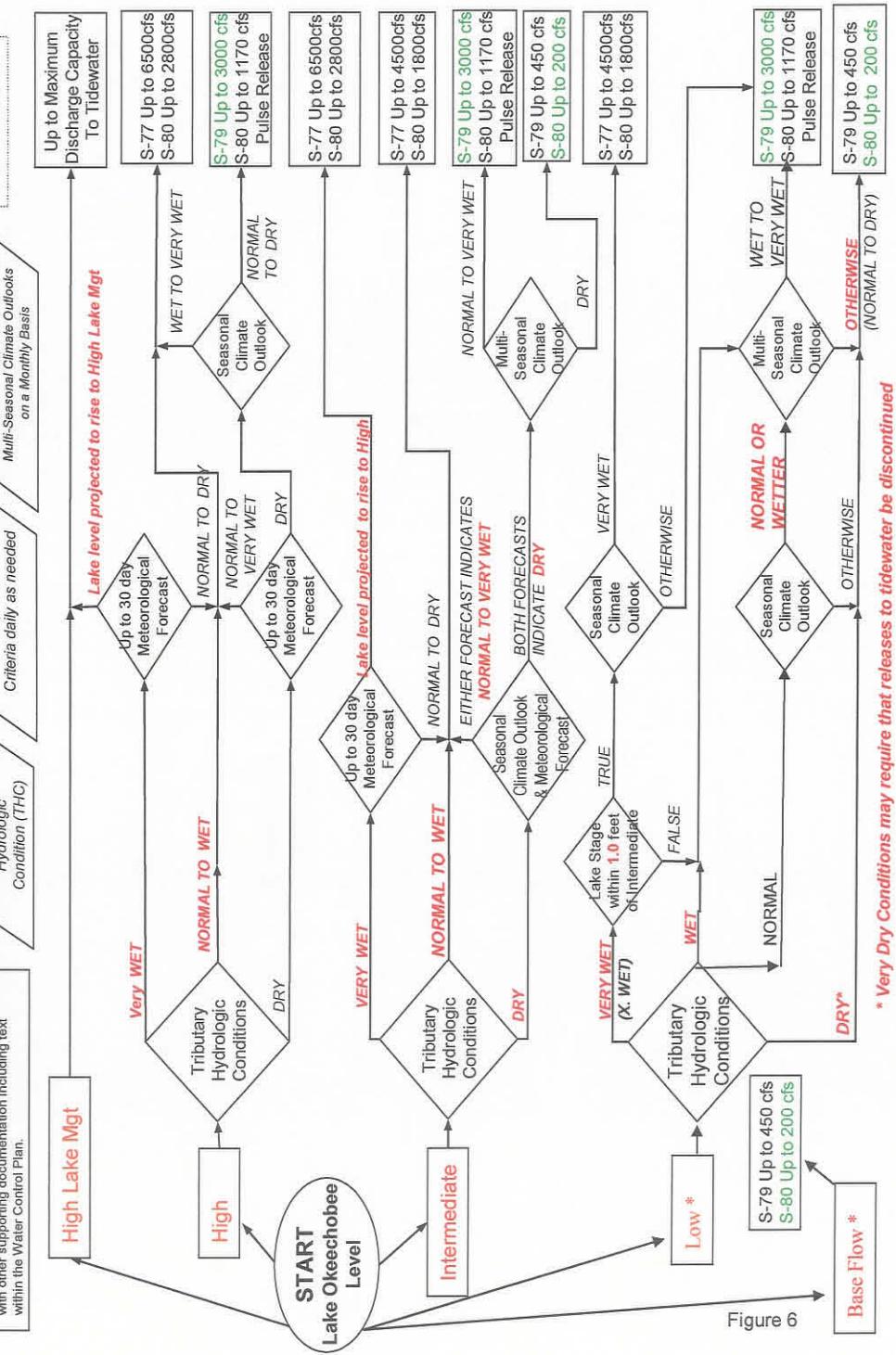


FIGURE 2-11: OPERATIONAL GUIDANCE, PART 2 FOR ALTERNATIVE D

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2.6.6. ALTERNATIVE E (T3)

Alternative E was developed through the collaborative efforts of the Corps and SFWMD, following LORSS PDT review of the updated 2006 SEIS alternatives (Alternatives A and B) and the new C and D alternatives. The Operational Guidance, Part 1 (releases to WCAs) for Alternative E remains unchanged from Alternative A, and the Operational Guidance with updated terminology is shown in Figure 2-5. The regulation schedule, and the Operational Guidance, Part 2, for Alternative E are shown in Figure 2-12 and Figure 2-13. Alternative E was developed from Alternative D, with the following changes:

1. Lake Okeechobee late season break points are changed from September 30 to November 1 for the top of the High, Intermediate, and Low sub-bands of the Operational Band to address the potential of late season hurricanes (consistent with Alternative C).
2. Inclusion of an October 1 breakpoint at 13.0 feet for the bottom of the baseflow Zone D0 (consistent with original 2006 SEIS Alternatives 2a and 4), to provide some protection to low lake levels at the end of the wet season.
3. Caloosahatchee Estuary Level 1 pulse level increased from average daily rate of 1600 cfs to 2000 cfs, to allow for increased releases below 2800 cfs to reduce higher lake levels and the associated higher volume releases.
4. Caloosahatchee Estuary Level 2 pulse level increased from average daily rate of 2300 cfs to 2500 cfs, to allow for increased releases below 2800 cfs to reduce higher lake levels and the associated higher volume releases.
5. Caloosahatchee Estuary Level 3 pulse level unchanged, at average daily rate of 3000 cfs.
6. Maximum Caloosahatchee Estuary discharges reduced from 4500 cfs to 4000 cfs when the Lake Okeechobee stage is within the Intermediate (THC: normal to wet) or Low (THC: very wet) sub-bands of the Operational Band.

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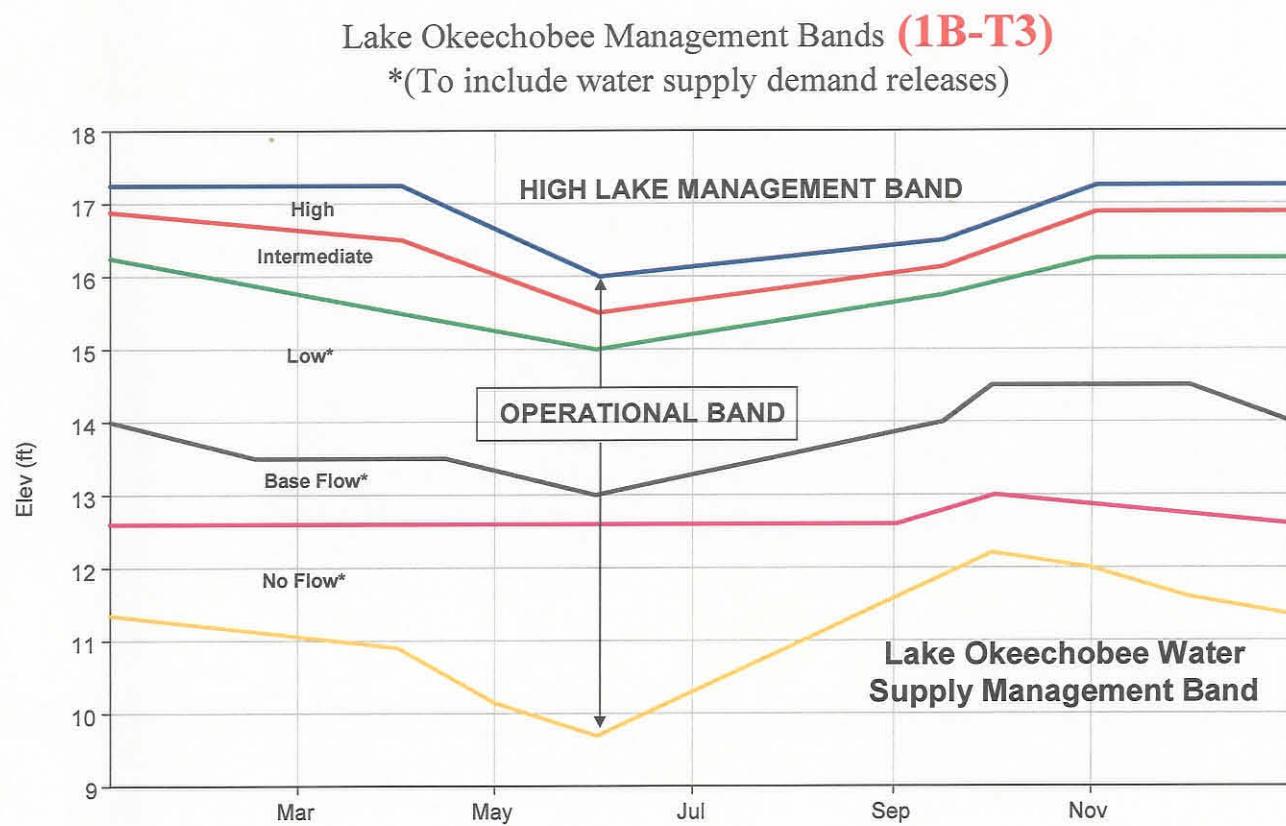


FIGURE 2-12: REGULATION SCHEDULE FOR ALTERNATIVE E

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Lake Okeechobee Operational Guidance (1B-T3)

Part 2: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)

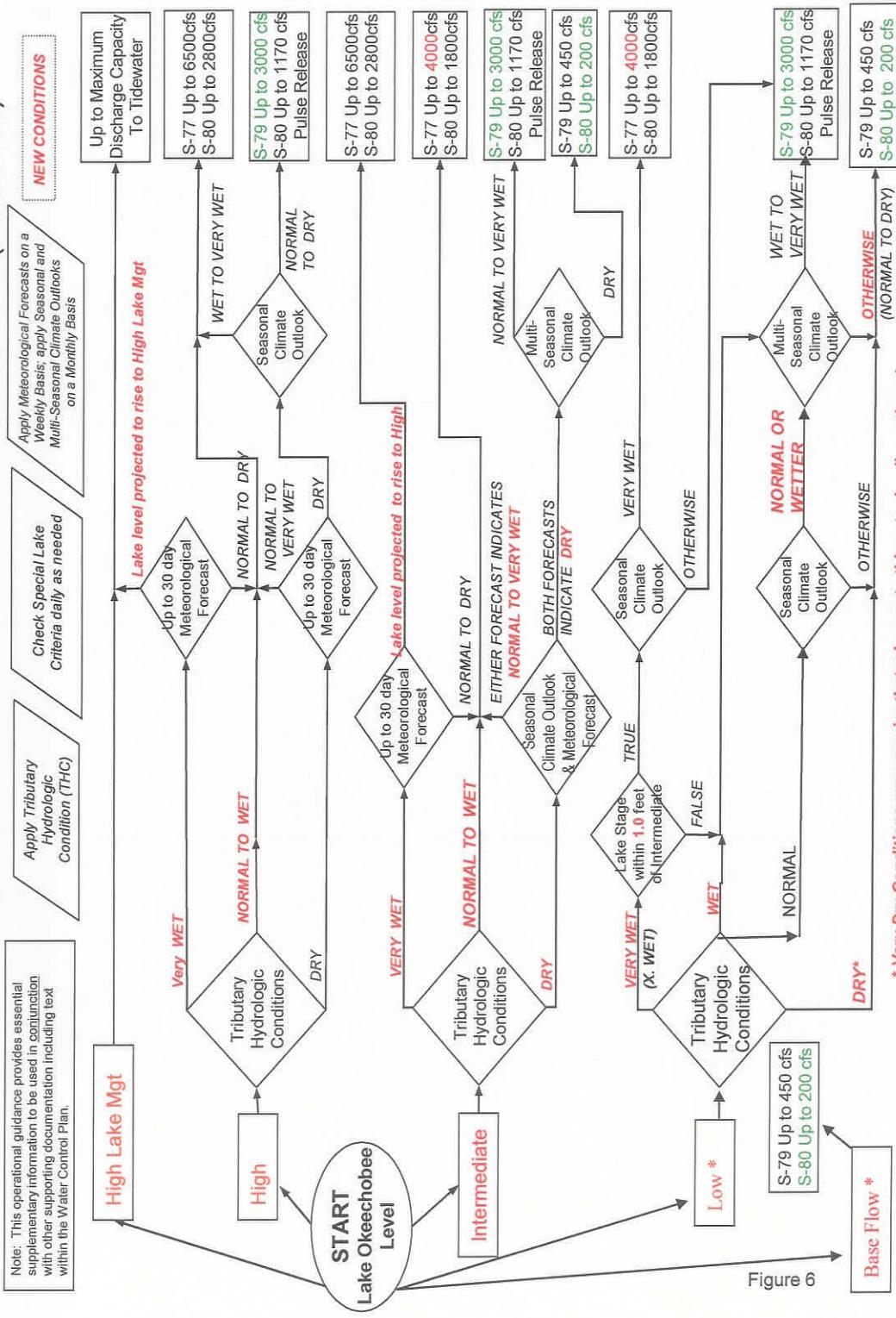


Figure 6

FIGURE 2-13: OPERATIONAL GUIDANCE, PART 2 FOR ALTERNATIVE E

* Very Dry Conditions may require that releases to tidewater be discontinued

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2.7. ISSUES AND BASIS FOR CHOICE

As listed in Section 1.8, many issues were identified and taken into account during the identification of the Preferred Alternative. Recommendations and feedback from the LORSS PDT, stakeholders and the general public were considered. Meeting the LORSS objectives was an important factor in choosing the Preferred Alternative.

2.8. IDENTIFICATION AND SUMMARY OF THE PREFERRED ALTERNATIVE

The Preferred Alternative is Alternative E (modeling name, T3).

2.9. ALTERNATIVES ELIMINATED FROM DETAILED EVALUATION

As previously discussed, only two alternatives from the 2006 draft SEIS were pulled forward into the evaluation in this revised draft SEIS. Conclusions from the evaluation of the 2006 draft SEIS, indicated that Alternatives 2a, 2a-m, and 4 did not perform adequately in meeting the goals and objectives of the LORSS. Therefore, these alternatives were eliminated from further detailed evaluation.

2.10. SUMMARY COMPARISON OF ALTERNATIVES

Table 2-2 lists alternatives that were considered and summarizes the major features and consequences of the proposed action and alternatives. Environmental effects of the alternatives are described in Section 6.

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TABLE 2-2: SUMMARY OF DIRECT AND INDIRECT IMPACTS

ALTERNATIVE ENVIRONMENTAL FACTOR	Alternative No Action	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
PROTECTED SPECIES	Potential adverse impacts to some species (snail kite, wood stork, Okeechobee gourd) due to extreme high lake occurrences	Beneficial due to better high lake stage performance; Potential for adverse effects due to more low lake occurrences.	Beneficial due to better high lake stage performance; Potential for adverse effects due to more low lake occurrences.	Beneficial due to better high lake stage performance; Potential for adverse effects due to more low lake occurrences.	Beneficial due to better high lake stage performance; Potential for adverse effects due to more low lake occurrences.	Beneficial due to better high lake stage performance; Potential for adverse effects due to more low lake occurrences.
FISH AND WILDLIFE RESOURCES	High lake stage causes adverse effects to lake F&W habitat; Potential for adverse effects to estuaries.	Benefit to lake resources due to lower lake schedule; Potential benefit to CE due to increase in preferred flow range; however increase in high flow events may be negative. Potential improvement to SLE due to decrease in high flow events and increase in preferred flow range. Potential negative effect for CE due to high flows of longer duration.	Benefit to lake resources due to lower lake schedule; Potential benefit to CE due to increase in preferred flow range; however increase in high flow events may be negative.	Benefit to lake resources due to lower lake schedule; Potential benefit to estuaries due to increase in preferred flow range. Additionally, reduced high flows to CE would be beneficial.	Benefit to lake resources due to lower lake schedule; Potential benefit to estuaries due to increase in preferred flow range. Additionally, reduced high flows to CE due to high flows of longer duration.	Benefit to lake resources due to lower lake schedule; Potential benefit to estuaries due to increase in preferred flow range. Additionally, base flow releases. Potential negative effect for CE due to high flows of longer duration.

ALTERNATIVE ENVIRONMENTAL FACTOR	Alternative No Action	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
						Preferred Alternative
VEGETATION	Adverse effects to lake SAV and emergent vegetation due to high water events; May encourage spread of cattail to interior of western marsh zone of lake.	Lake vegetation would benefit due to reduced high lake occurrences; Increased low lake occurrences benefit plant seed bank germination. See Essential Fish Habitat (EFH) section below for estuary effects.	Lake vegetation would benefit due to reduced high lake occurrences; Increased low lake occurrences benefit plant seed bank germination. See EFH section below for estuary effects	Lake vegetation would benefit due to reduced high lake occurrences; Increased low lake occurrences benefit plant seed bank germination. See EFH section below for estuary effects	Lake vegetation would benefit due to reduced high lake occurrences; Increased low lake occurrences benefit plant seed bank germination. See EFH section below for estuary effects	Lake vegetation would benefit due to reduced high lake occurrences; Increased low lake occurrences benefit plant seed bank germination. See EFH section below for estuary effects
FLOOD CONTROL	Greater potential for adverse effects due to higher top zone regulation schedule.	Reduces high lake stage, improving flood control.	Reduces high lake stage, improving flood control.	Reduces high lake stage, improving flood control.	Reduces high lake stage, improving flood control.	Reduces high lake stage, improving flood control.
WATER QUALITY	No improvement expected due to high lake elevation.	Potential for indirect benefits due to reduction >15 ft lake stage; Minimal change, if any, to estuary W/Q.	Potential for indirect benefits due to reduction >15 ft lake stage; Minimal change, if any, to estuary W/Q.	Potential for indirect benefits due to reduction >15 ft lake stage; Minimal change, if any, to estuary W/Q.	Potential for indirect benefits due to reduction >15 ft lake stage; Minimal change, if any, to estuary W/Q.	Potential for indirect benefits due to reduction >15 ft lake stage; Minimal change, if any, to estuary WQ.
HISTORIC PROPERTIES	No effect.	No effect.	No effect.	No effect.	No effect.	No effect.

ALTERNATIVE ENVIRONMENTAL FACTOR	Alternative No Action	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Preferred Alternative						
RECREATION	May negatively affect sport fishery due to loss of SAV and emergent vegetation.	Potential improvement to lake sport fishery due to reduced high lake stage events.	Potential improvement to lake sport fishery due to reduced high lake stage events.	Potential improvement to lake sport fishery due to reduced high lake stage events.	Potential improvement to lake sport fishery due to reduced high lake stage events.	Potential improvement to lake sport fishery due to reduced high lake stage events.
AESTHETICS	Potential for adverse effects due to high water levels impacting vegetation and wildlife.	May improve lake aesthetics due to improved lake schedule.	May improve lake aesthetics due to improved lake schedule.	May improve lake aesthetics due to improved lake schedule.	May improve lake aesthetics due to improved lake schedule.	May improve lake aesthetics due to improved lake schedule.
NAVIGATION	No significant adverse effects expected. Days below 12.56 ft NGVD are 2,876	Adverse effects expected due to increased days below 12.56 ft. Total days below are 4,839.	Adverse effects expected due to increased days below 12.56 ft. Total days below are 4,922.	Adverse effects expected due to increased days below 12.56 ft. Total days below are 4,909.	Adverse effects expected due to increased days below 12.56 ft. Total days below are 5,156.	Adverse effects expected due to increased days below 12.56 ft. Total days below are 5,128 within the 36 yr POR.
ECONOMICS	Minimal effects expected.	Minimal effects expected.	Minimal effects expected.	Minimal effects expected.	Overall, minimal effects expected.	Overall, minimal effects expected.

ALTERNATIVE ENVIRONMENTAL FACTOR	Alternative A No Action	Alternative B	Alternative C	Alternative D	Alternative E Preferred Alternative
WATER SUPPLY	No effect.	Minimal effect compared to the No Action.	Minimal effect compared to the No Action.	Minimal effect compared to the No Action.	For details, refer to sections 6.12 and 6.19.
ESSENTIAL FISH HABITAT	High volume releases may negatively affect EFH in estuaries.	Increase in preferred flows may benefit CE and SLE. No reduction in mean monthly high flows to CE. Reduction in high flows to SLE may benefit EFH.	Increase in preferred flows may benefit CE and SLE. No reduction in mean monthly high flows to CE. Reduction in high flows to SLE may benefit EFH.	Minimizing flows >2800 cfs to CE, and the increase in preferred flow range to SLE and CE may benefit EFH.	Minimizing flows >2800 cfs to CE and >2000 to SLE is beneficial. An increase in preferred flow range to SLE and CE may benefit EFH. Base flow may benefit EFH.

3. PREFERRED ALTERNATIVE

3.1. SUMMARY OF OPERATIONAL FEATURES

The Preferred Alternative resulted in proposed water management operational guidance to be used on a daily basis in the management of Lake Okeechobee. The proposed operational guidance includes: 2007 Lake Okeechobee Interim Regulation Schedule Part A through D (Figure 3-1 through Figure 3-4 respectively), THCs, weather forecasts, climate-based hydrologic outlooks, and historical as well as projected lake level information.

Through the Preferred Alternative, management of Lake Okeechobee water levels and determination of Lake Okeechobee releases to the WCAs and to tide (estuaries) is based on seasonally varying lake elevations divided into three bands as shown on the proposed 2007 Lake Okeechobee Interim Regulation Schedule Part A (Figure 3-1). These bands include "High Lake Management" (top band on Figure 3-1), "Operational" (middle band on Figure 3-1), and "Water Shortage Management" (bottom band on Figure 3-1). The High Lake Management Band is meant to address public health and safety, especially related to the structural integrity of HHD by providing the ability to make releases up to the maximum capacity that lake outlets will allow. The Operational Band is meant to facilitate authorized project purposes by providing the ability to make releases of various volumes, including no release; Lake Okeechobee outlet canals should be maintained within their optimum water management elevations. The Water Shortage Management Band pertains to low lake levels which necessitate rationing water supplies; Lake Okeechobee outlet canals may be maintained below their optimum water management elevations. The water supply releases made within this band are made according to the SFWMD's draft LOWSM Plan.

The 2007 Lake Okeechobee Interim Regulation Schedule Part B (Figure 3-1) further defines the bands of the regulation schedule. In Part B, the Operational Band is subdivided into additional bands and sub-bands that are directly related to defining allowable Lake Okeechobee releases to the WCAs and to tide (estuaries). In general as lake levels rise through the higher sub-bands, the allowable release rates increase.

Evaluation of the LORSS Preferred Alternative over the POR (1965 to 2000) shows that the proposed regulation schedule releases to the WCAs and to the estuaries will reduce the likelihood of lake levels that both increase the probability of a breach of the HHD and also contribute to poor ecological conditions within Lake Okeechobee. For Lake Okeechobee, a high lake level can lead to the decline of emergent and submerged vegetation which is essential habitat for the lake's fish and wildlife populations.

The LORSS Preferred Alternative provides the ability to make long-term, low-volume releases to the Caloosahatchee Estuary, St. Lucie Estuary, and WCAs. These releases include low-volume pulse releases and base flow releases to the Caloosahatchee

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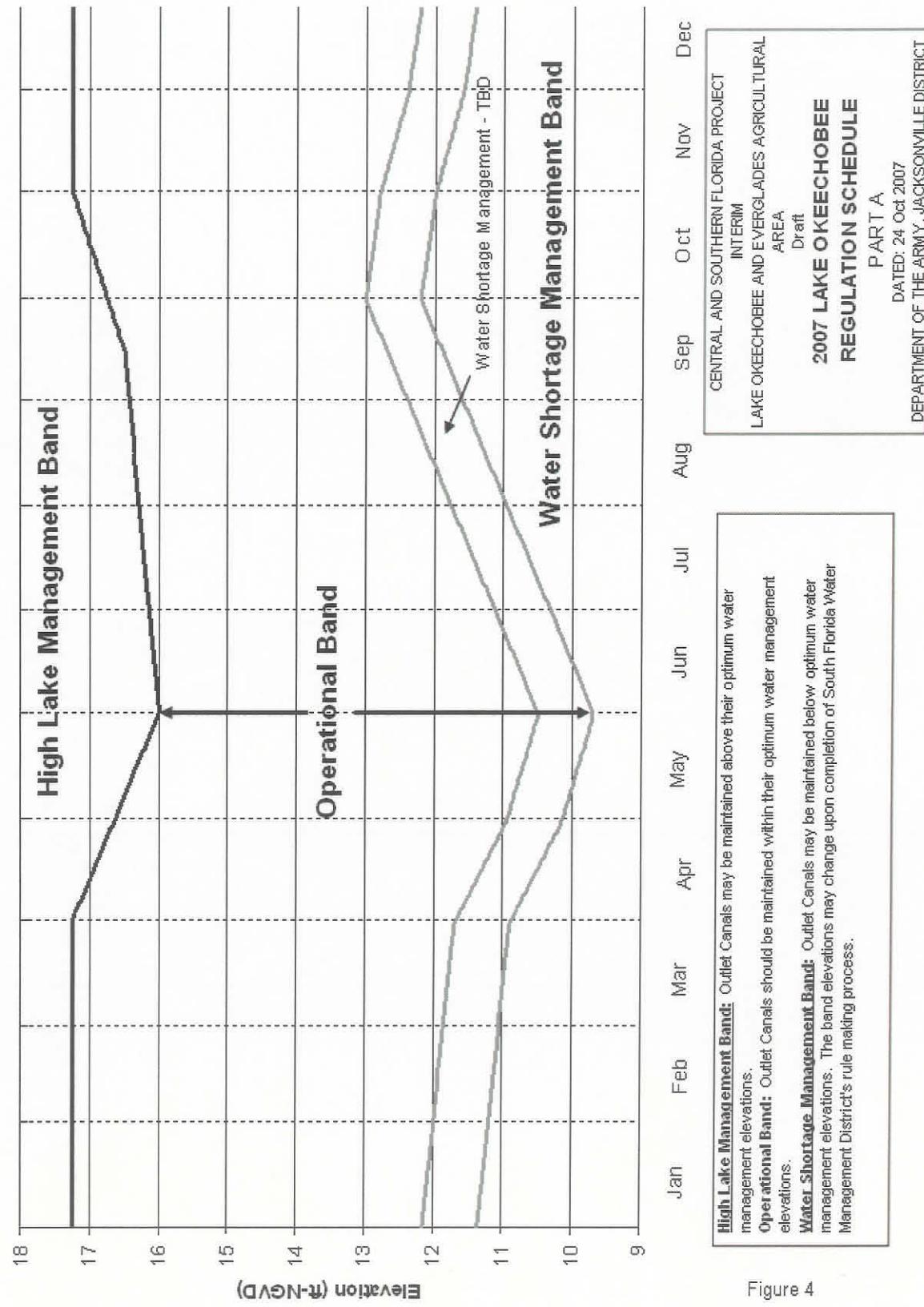


Figure 4

FIGURE 3-1: 2007 LAKE OKEECHOBEE INTERIM REGULATION SCHEDULE PART A

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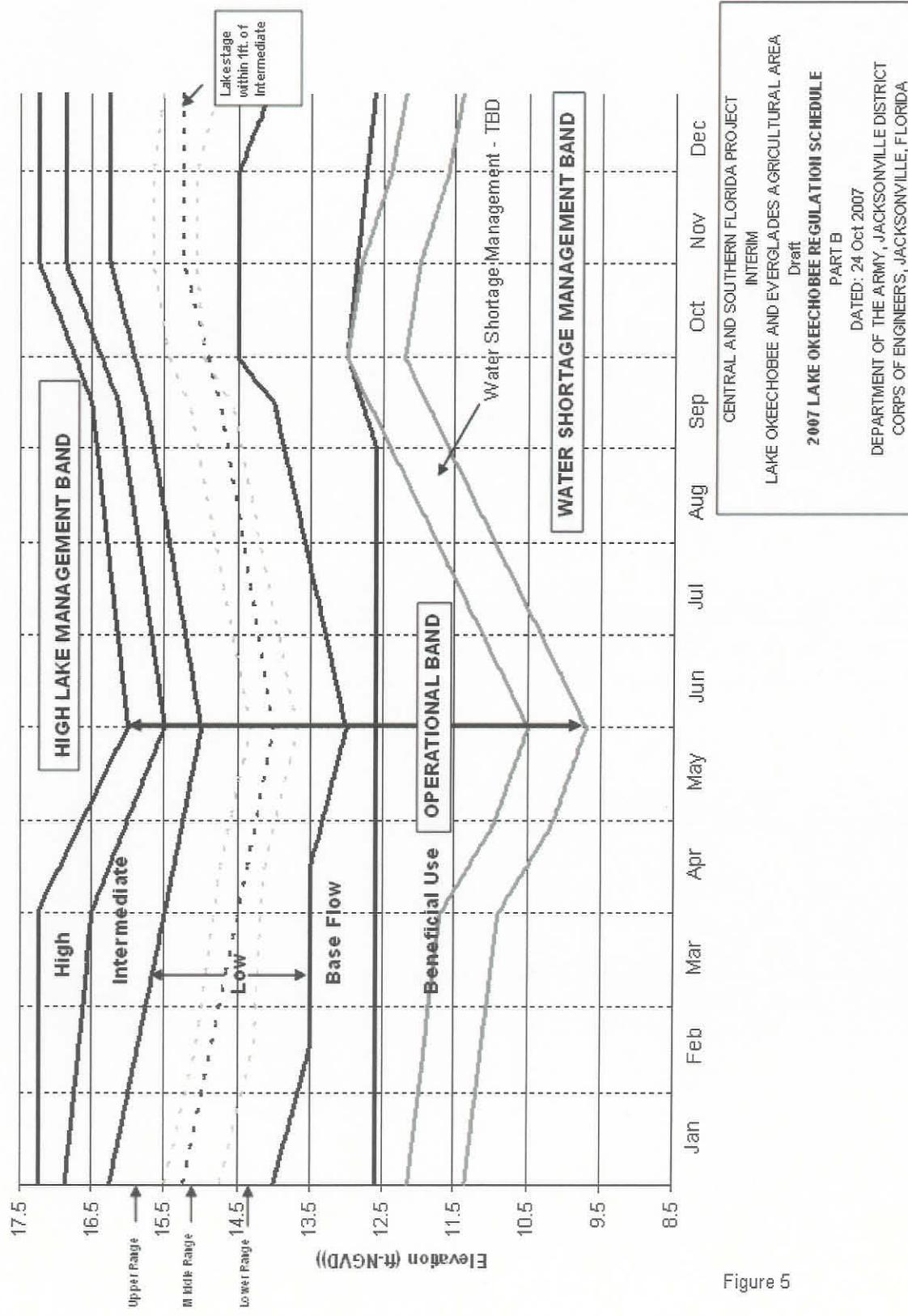


FIGURE 3-2: 2007 LAKE OKEECHOBEE INTERIM REGULATION SCHEDULE PART B

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Lake Okeechobee Operational Guidance

Part C: Establish Allowable Lake Okeechobee Releases to the Water Conservation Areas

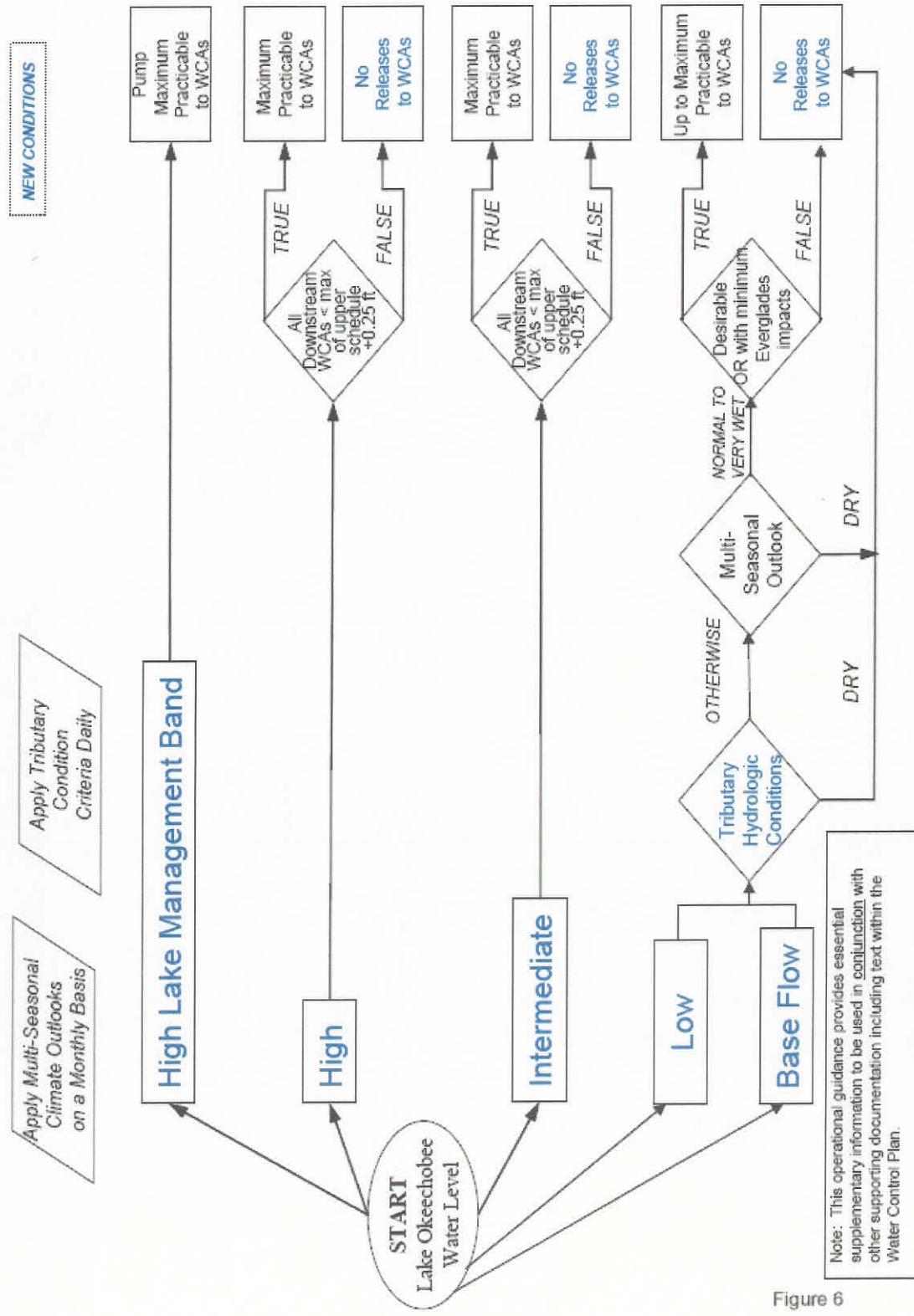


Figure 6

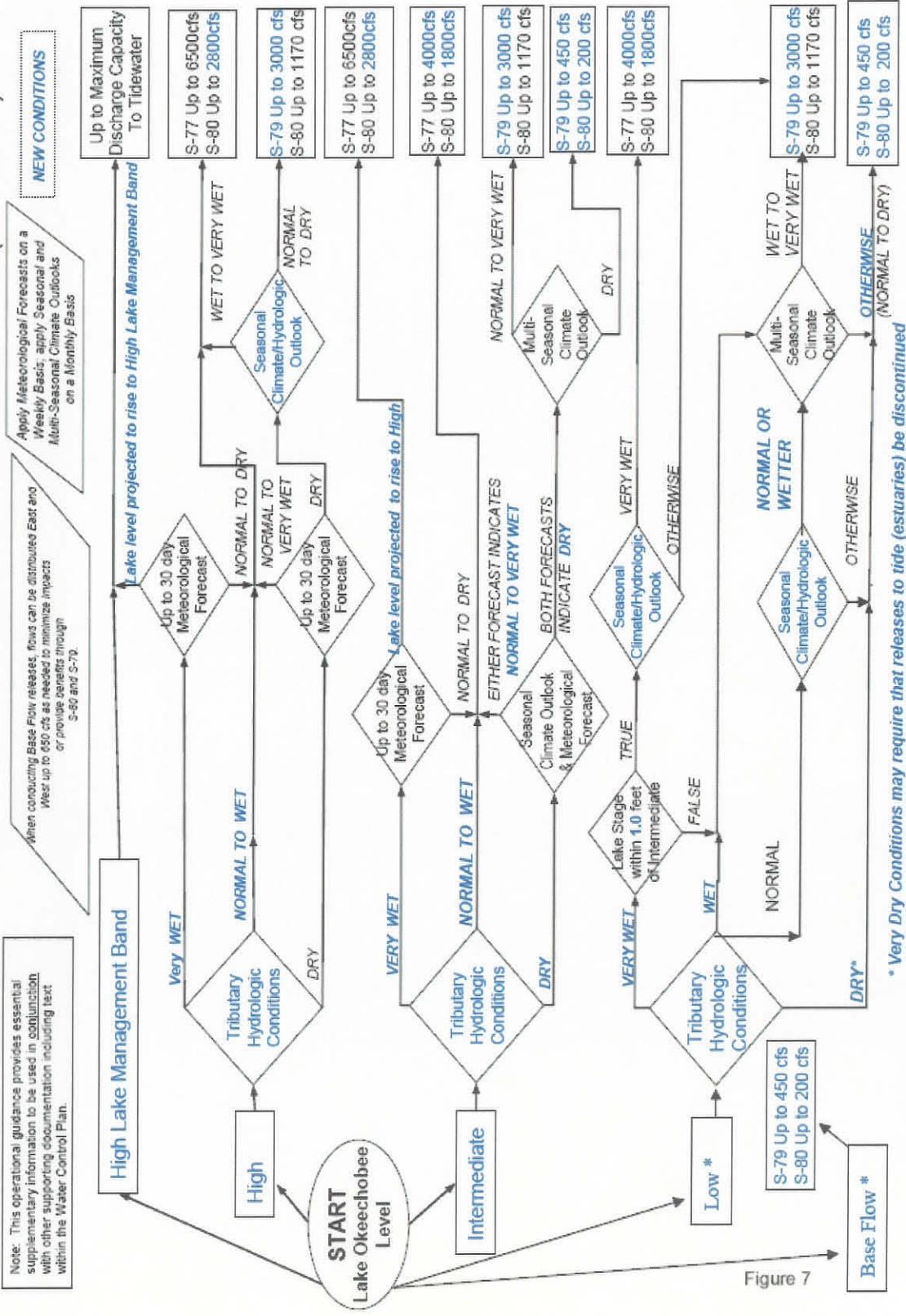
Note: This operational guidance provides essential supplementary information to be used in conjunction with other supporting documentation including text within the Water Control Plan

FIGURE 3-3: 2007 LAKE OKEECHOBEE INTERIM BEGINNING SCHEDULE FOR PART C

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Lake Okeechobee Operational Guidance

Part D: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)



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and St. Lucie estuaries that allow Lake Okeechobee to be maintained at more desirable levels throughout the year. A pulse release attempts to simulate a natural rainstorm event within the basins. The receiving body would respond to the pulse release in a similar fashion as if a rainstorm had occurred in the upstream watershed. Although an average flow rate is targeted for the duration of the pulse release, daily releases vary. The pulse releases and base flow releases are intended to regulate lake levels and reduce the potential for future prolonged high-volume releases to the estuaries. The base flow releases also provide a benefit of maintaining desirable salinity levels in the estuaries. By regulating lake levels, these low-volume releases improve public health and safety performance by reducing risk to the HHD and provide improved benefits for the health of Lake Okeechobee and the estuaries.

3.2. PROPOSED OPERATIONAL GUIDANCE

The Operational Guidance, contained in Appendix A, establishes the allowable quantity, timing, and duration of releases from Lake Okeechobee to the WCAs and to tide (estuaries). Water management decisions will utilize the 2007 Lake Okeechobee Interim Regulation Schedule Parts A through D (Figure 3-1 through Figure 3-4) to provide guidance on releases from Lake Okeechobee. Information shown on Part C and Part D (Figure 3-1 and Figure 3-4) is utilized to establish the allowable releases to the WCAs and the allowable releases to tide (estuaries), respectively.

In January 2007, the SFWMD Governing Board passed a resolution requesting the Corps to take into consideration increased storage capacity on SFWMD public and private lands in the Okeechobee Watershed to receive Lake Okeechobee water releases. A copy of the SFWMD resolution and past correspondence is provided in Appendix H. The SFWMD lands for storage, as described in the resolution, would be utilized to achieve a more refined balance between the competing needs of Lake Okeechobee and estuarine ecosystems, flood control and water supply. The Corps strongly supports this state initiative and continues to work with SFWMD to utilize their public/private lands for Lake Okeechobee water storage in conjunction with operation of the Preferred Alternative. When the Operational Guidance and/or basin conditions between Lake Okeechobee and the estuaries result in flows deemed undesirable by SFWMD to the estuaries, the SFWMD may seek to store Lake Okeechobee water on available SFWMD designated lands. As Comprehensive Everglades Restoration Plan (CERP) reservoirs designed to receive Lake Okeechobee releases become available, they will be operated according to the operational guidance established for those projects. These efforts are intended to reduce undesirable lake releases to the estuaries by first making lake releases to alternative storage areas to minimize flows that are above the estuary's biologically-derived maximum flow criteria.

The "Lake level projected to rise to" phrase in the Lake Okeechobee Operational Guidance to Tide (Figure 3-4) can be determined on a daily basis. Information to be considered includes, but is not necessarily limited to, the following variables: climate forecasts, release constraints due to downstream conditions, actual lake level rate of rise, historical lake levels, and the state of the C&SF Project (including the availability of new facilities proposed by the CERP).

3.3. LAKE OKEECHOBEE MANAGEMENT BANDS

The proposed operational guidance for management of the Lake Okeechobee water levels and outlet canals has three distinct bands defined by seasonal fluctuations of the lake level (Figure 3-1). Each management band is designed to achieve specific objectives consistent with Congressionally-authorized purposes for Lake Okeechobee. The bottom band, at the lower lake levels, is the Water Shortage Management Band. In this band, water in Lake Okeechobee will be managed in accordance with the Water Shortage Plan established by SFWMD. Outlet canals may be maintained below their optimum water management elevations in this band. The top band, at the higher lake levels, is the High Lake Management Band. The goal for lake management within this band is to quickly lower high lake levels. This will make lake storage available for use during the next rainfall event, to reduce impacts on Lake Okeechobee's submerged aquatic vegetation (SAV) and to reduce the risk to public health and safety, including but not limited to HHD integrity issues; outlet canals may be maintained above their optimum water management elevations in this band. The middle and largest band is the Operational Band, which includes several sub-bands (High, Intermediate, Low, Base Flow, and Beneficial Use Sub-Bands). It is anticipated that the majority of time, lake levels will be within the Operational Band, and Lake Okeechobee would be managed according to the operational criteria established for the sub-bands of the Operational Band, including provisions to meet water supply demands for ENP, salinity control, regional groundwater control, agricultural irrigation, municipalities, and industry. Outlet canals should be maintained within their optimum water management elevations in this band.

Within the High, Intermediate, Low, and Base Flow Sub-Bands, the allowable release from Lake Okeechobee to the WCAs is defined by lake level, hydrologic conditions, effect of desired release on the Everglades, treatment capacity of Storm Water Treatment Areas (STAs), and downstream WCA level(s), as well as long-term climate-based hydrologic outlooks (Figure 3-3). Also within the Operational Band and its sub-bands, the allowable release from Lake Okeechobee to the estuaries is defined by lake level, the trend of the lake level, hydrologic conditions, short-term weather forecasts, and long-term climate-based hydrologic outlooks (Figure 3-4). A detailed description of the management bands follows.

Water Shortage Management Band—varies seasonally between 9.7 to 13.0 ft., NGVD and below. Operations in this band are governed by the SFWMD's LOWSM (**NOTE: draft Water Shortage Management Band elevations may change upon completion of SFWMD's rule making process.**). The goal of this band is to manage existing water supply contained within Lake Okeechobee in accordance with SFWMD rules and guidance.

High Lake Management Band—varies seasonally between elevations 16.0 and 17.25 ft., NGVD and above. The goal of this band is to reduce the risk to public health and safety and to make releases to lower the lake below the High Lake Management Band as soon as possible. In this High Lake Management Band, it is of the utmost importance that the lake level be reduced as rapidly as possible to make storage

available for the next possible rainfall event, to relieve stress on the HHD, and to reduce impacts on Lake Okeechobee's littoral zone. Releases up to the maximum discharge capacity will be made to tide and up to maximum practicable discharges will be pumped to the WCAs and made available to CERP impoundments (as they become available). In an effort to reduce undesirable lake releases to the estuaries, Lake Okeechobee water will also be made available to the SFWMD for their use to store on lands designated by SFWMD (as they become available). Within the High Lake Management Band, the allowable release from Lake Okeechobee to the WCAs and to the estuaries is defined by the lake level as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part C and Part D (Figure 3-3 and Figure 3-4), respectively. Actual rates of release from Lake Okeechobee will vary depending on but not limited to downstream channel conditions, estuary conditions, conditions in the WCAs, and conditions in the STAs. Although unlikely to be required due to wet conditions that are likely to exist when lake levels are within this band, Lake Okeechobee releases to meet water supply demands (for ENP, salinity control, regional groundwater control, agricultural irrigation, municipalities, industry, and the environment) may be made at any time within the High Lake Management Band.

Operational Band-the largest management band varies seasonally between 9.7 ft. at its lowest point and 17.25 ft., NGVD at its highest point. (**NOTE: draft Water Shortage Management Band elevations may change upon completion of SFWMD's rule making process which would raise the bottom of the Operational Band-9.7 ft.**). The goal of the Operational Band is to manage the lake stage to balance all authorized project purposes. This involves use of flood control releases, environmental releases, base flow releases, and water supply releases. In an effort to reduce undesirable lake releases to the estuaries, Lake Okeechobee water may be stored in CERP reservoirs (as they become available) or SFWMD may seek to store Lake Okeechobee water on available SFWMD designated lands. The USACE will coordinate operations with the SFWMD as necessary. For Lake Okeechobee, an environmental release can be considered as a release from Lake Okeechobee to benefit the lake ecosystem, downstream ecosystems, and/or upstream ecosystems. For Lake Okeechobee, a base flow release to the Caloosahatchee Estuary is a release from Lake Okeechobee at S-77 to achieve a 450 cfs flow at S-79. A base flow release to the St. Lucie Estuary is a release at S-308 to achieve a 200 cfs flow at S-80. When conducting base flow releases, flows up to 650 cfs can be distributed East and West as needed to minimize impacts or provide additional benefits. Very dry THCs may require that releases to tide (estuaries) be discontinued. For Lake Okeechobee, a water supply release can be considered a release from Lake Okeechobee to meet water supply demands (for ENP, salinity control, regional groundwater control, agricultural irrigation, municipalities, industry and the environment). Lake Okeechobee releases to meet water supply demands may be made at any time within the Operational Band. Within the Operational Band, several sub-bands have been established to further define lake releases. As described below, these bands include the Beneficial Use Sub-Band, Base Flow Sub-Band, Low Sub-Band, Intermediate Sub-Band, and High Sub-Band.

Beneficial Use Sub-Band: This sub-band varies seasonally between elevation 9.7 ft. and 13.0 ft., NGVD at its highest point. (**NOTE: draft Water Shortage Management Band elevations may change upon completion of SFWMD's rule making process which would raise the bottom of the Beneficial Use Sub-Band-9.7 ft.**). Except for navigation, SFWMD allocates water to various users in this sub-band. Navigation can typically be supported by releases from Lake Okeechobee that are conducted for other authorized project purposes. Fish and wildlife enhancement and/or water supply deliveries for environmental needs may involve conducting an environmental release from Lake Okeechobee through the SFWMD's "Adaptive Protocols" or other SFWMD authorities.

Base Flow Sub-Band: This sub-band varies seasonally between elevation 12.6 ft. and 14.5 ft., NGVD. In this band, the allowable release from Lake Okeechobee to the WCAs is defined by lake level, hydrologic conditions, effect of desired release on the Everglades, treatment capacity of STAs, downstream WCA level(s), THCs, and climate-based hydrologic outlooks as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part D (Figure 3-4). Also in this sub-band, continuous, low-volume releases can be made to the Caloosahatchee Estuary and the St. Lucie Estuary. Base flow limits are defined as up to 450 cfs measured at S-79, and up to 200 cfs measured at S-80. If the basin runoff between Lake Okeechobee and the estuary is less than this "base flow", then Lake Okeechobee releases are made to supplement the difference. These base flow releases of excess lake water may have environmental benefits to the estuaries and help to reduce the chances of subsequent high volume discharges. In addition, the SFWMD may allocate water to the environment through its "Adaptive Protocols" or other SFWMD authorities.

Low Sub-Band: This sub-band varies seasonally between elevation 13.0 ft. and 16.25 ft., NGVD. In this sub-band, operations for releases to the WCAs and base flow to the estuaries will be conducted consistent with the Base Flow Sub-Band. Lake Okeechobee releases to the estuaries that are greater than base flow are allowed within this sub-band and are defined by lake level, hydrologic conditions, lake level's distance from the Intermediate Sub-Band, THCs, and climate-based hydrologic outlooks as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part D (Figure 3-4). As shown on Part B, this sub-band was divided into thirds (Upper Range, Middle Range, Lower Range). Within the Upper Range, the pulse release to the Caloosahatchee Estuary is up to 3000 cfs while to the St. Lucie Estuary it is up to 1170 cfs (3000/1170). The pulse release in the Middle Range and the Lower Range is 2500/950 and 2000/730, respectively. Within the Low Sub-Band, the release from Lake Okeechobee to the WCAs is defined by lake level, THCs, effect of desired release on the Everglades, downstream WCA level(s), and the multi-seasonal climate-based hydrologic outlook as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part C (Figure 3-3). The maximum allowable lake releases to the WCAs and estuaries is provided as follows:

- (1) To WCAs-When THCs and the multi-seasonal climate/hydrologic outlook are not in their dry classifications, then up to maximum practicable release to the WCAs

are allowable if the release is beneficial to, or will result in minimum Everglades impacts. Both the quantity and quality of Lake Okeechobee water will be considered.

- (2) To Estuaries-When tributary conditions are very wet, the lake level is within 1.0 foot of the Intermediate Sub-Band, and the seasonal climate forecast is very wet, then lake releases up to 4000 cfs at S-77 and up to 1800 cfs at S-80 (4000/1800) are allowable.
- (3) To Estuaries-When the lake level is not within one foot of the Intermediate Sub-Band, or tributary conditions are not very wet, and the multi-seasonal climate/hydrologic outlook is wet, then lake releases up to 3000 cfs at S-79 and up to 1170 cfs at S-80 (3000/1170) are allowable. These releases are intended to be made in a pulse release that is sensitive to the estuarine environment.

Intermediate Sub-Band: This sub-band varies seasonally between elevation 15.0 ft. to elevation 16.88 ft., NGVD. In this sub-band, operations for base flow to the estuaries will be conducted consistent with the Base Flow Sub-Band. Lake Okeechobee releases to the estuaries that are greater than base flow are allowed within this sub-band and are defined by lake level, THCs, the projected rise of Lake Okeechobee, short term meteorological forecasts, seasonal hydrologic outlooks, and climate-based hydrologic outlooks as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part D (Figure 3-4). The allowable release from Lake Okeechobee to the WCAs is defined by lake level and downstream WCA level(s), as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part C (Figure 3-3). The maximum allowable lake releases to the WCAs and estuaries is provided as follows:

- (1) To WCAs-When all downstream WCAs are less than a quarter of a foot above the maximum elevation of their regulation schedules, then up to maximum practicable release to the WCAs are allowable. Downstream WCAs refer to the WCAs downstream of the WCA receiving Lake Okeechobee discharges. For example, if it is desired to make a release to WCA-3A (via STA-3/4), then WCA-1 and WCA-2A water levels do not constrain the release to WCA-3A since they are upstream of WCA-3A. However, if it is desired to make a release to WCA-2A (via STA-3/4), and if the WCA-3A water level was higher than a quarter of a foot above the maximum of its regulation schedule, then no release to WCA-2A would be made.
- (2) To Estuaries-When tributary conditions are very wet and the lake level is projected to rise into the High Sub-Band, lake releases up to 6500 cfs at S-77 and up to 2800 cfs at S-80 (6500/2800) are allowable.

High Sub-Band: This sub-band varies seasonally between elevation 15.5 ft. at its lowest point and elevation 17.25 ft., NGVD. In this sub-band, releases to the Caloosahatchee Estuary of up to 3000 cfs measured at S-79, and up to 1170 cfs to the St. Lucie Estuary measured at S-80, can always be made for management of the lake

level. The allowable lake releases to the estuaries are defined by lake level, THCs, the projected rise of the lake, short term weather forecasts, and the seasonal climate/hydrologic outlook as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part D (Figure 3-4). The allowable release from Lake Okeechobee to the WCAs is defined by lake level and downstream WCA level(s), as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part C Figure 3-3). The maximum allowable lake releases to the WCAs and estuaries is provided as follows:

- (1) To WCAs-When all downstream WCAs are less than a quarter of a foot above the maximum elevation of their regulation schedules, then up to maximum practicable release to the WCAs are allowable.
- (2) To Estuaries-When THCs are very wet and the lake level is projected to rise into the High Lake Management Band, then lake releases up to maximum discharge capacity are allowable.

3.4. MAKE-UP RELEASE DESCRIPTION

Historically, the planned Lake Okeechobee releases to tide (estuaries) have been subject to reduction or prevention by downstream conditions such as downstream local basin runoff, the tidal cycle, tidal storm surge, and spawning in the estuaries. Similarly, planned Lake Okeechobee releases to the WCAs have also been limited by high water levels in the WCAs, STA treatment capacity limits, and limited or no conveyance capacity in the primary canals within the EAA. When these conditions have occurred in the past, the releases have been delayed or discontinued to prevent adverse effects downstream from Lake Okeechobee. To address this issue, proposed operational guidance includes conducting releases from Lake Okeechobee to tide and/or to the WCAs (via STAs) to make up releases that were previously reduced or prevented. These make-up releases from Lake Okeechobee to tide (estuaries) and WCAs will occur as soon as possible and may occur when Parts C and D (Figures 6 and 7) do not allow releases or prescribe a lower volume release. The lake make-up releases to tide (estuaries) would be limited to a pulse release from Lake Okeechobee not to exceed 2800 cfs measured at S-79, and 2000 cfs at the St. Lucie Estuary when the lake level is below the Intermediate Sub-Band. This 2000 cfs at the St Lucie Estuary includes releases from all C&SF Project structures that discharge into the St Lucie Estuary. The environmental effects of this action are similar to those modeled, and would be no greater than those effects already discussed in Section 6 of this SEIS.

If an evaluation leads to implementation of a make up release, the make up release volume will be equal to or less than the volume of water that was reduced or prevented. The make up releases would essentially allow the ability to postpone Lake Okeechobee releases. The make up release may or may not be implemented, conditions will be monitored to determine the need to implement.

3.5. DECISION-MAKING PROCESS

The decision-making process for Lake Okeechobee water management operations considers all Congressionally-authorized project purposes. The decision-making process to determine quantity, timing, and duration of the potential release from Lake Okeechobee includes consideration of various information related to water management. This information includes but is not necessarily limited to: C&SF Project conditions, historical lake levels, estuary conditions/needs, lake ecology conditions/needs, WCA water levels, STA available capacity, current climate conditions, climate forecasts, hydrologic outlooks, projected lake level rise/recession, and water supply conditions/needs.

Part A of the 2007 Lake Okeechobee Interim Regulation Schedule (Figure 3-1) can be considered a starting point in the decision-making process for Lake Okeechobee water management operations. Part A allows a quick visual determination of which of the general management bands applies to the current lake stage.

Use of the 2007 Lake Okeechobee Interim Regulation Schedule Parts B through D (Figure 3-2 through Figure 3-4) will result in the determination of releases from Lake Okeechobee. The elevation guidelines include appropriate variations by season to conform to competing project purposes. As with WSE, recreation and navigation is provided for when water is available and/or through releases conducted for other project purposes.

The release to be implemented will be limited to the allowable release determined from Part C and Part D (Figure 3-3 and Figure 3-4), except as noted in the Make-up Release Description. Releases can vary up to the allowable release based on consideration of current and anticipated conditions/needs stated in the first paragraph of this section. This process allows for the quantity, timing, and duration of the releases to be performed to address the competing needs associated with water resources and the Congressionally-authorized project purposes.

When operating near band and sub-band limits, up to 30-day forecasts will be made and releases will be scheduled to lower or maintain Lake Okeechobee at the desired level during the 30-day period. Scheduling of releases may include the adjustment of band/sub-band limits when determining the release to implement. Factors considered in adjusting the band/sub-band limits would include but not be limited to: availability of STA treatment capacity, SFWMD designated lands, CERP reservoirs, and the condition of tributary basins. The band/sub-band adjustment is meant to transition into and out of sub-bands by allowing flows to gradually increase or decrease between sub-bands. An example of this adjustment would be: a condition above is occurring, lake level is 0.2 feet below the Intermediate Sub-Band and projected to rise into the Intermediate Sub-Band, then the allowable Lake Okeechobee release would be determined by following Part D with the lake level considered to be in the Intermediate Sub-Band (not 0.2 ft. below the Intermediate Sub-Band). The environmental effects of utilizing forecasts to gradually increase or decrease Lake Okeechobee releases are similar to those effects discussed in Section 6, which are based on modeling simulations.

3.6. ADDITIONAL OPERATIONAL FLEXIBILITY

It is anticipated that future events similar to those experienced over the POR (1965-2000) will be effectively managed by the Preferred Alternative. The Preferred Alternative was also simulated for the 2001 through 2005 period, and deemed effective for managing high lake elevations under this set of conditions. Occasionally, additional operational flexibility will be used to address circumstances (i.e., hydrologic conditions, lake levels, spawning in the estuaries, downstream runoff, etc.) that were not evaluated in the Preferred Alternative for the POR. Additional operational flexibility provides water managers the ability to consider releases from Lake Okeechobee to the WCAs and to tide (estuaries) to minimize damages or to meet project purposes when the 2007 Lake Okeechobee Interim Regulation Schedule Parts A through D (Figure 3-1 through Figure 3-4) are not effective at managing lake levels consistent with the intent of the Preferred Alternative.

Release decisions will take into account the estuaries biologically-derived maximum flow, future water supply demands, C&SF Project system-wide conditions, and lake ecological conditions, as appropriate. Consideration of the concern for public health and safety is the USACE's highest priority. When conditions exist for such releases, experts on estuarine, lake, and wetland ecology would provide scientific input with regard to the effects these release would have on the environment. The environmental effects would be evaluated on the basis of existing conditions in the ecosystems, as quantified by the performance measures described in Section 4 of this SEIS. Additionally, these operations would have environmental effects similar to the effects discussed in Section 6, which are based on modeling simulations. The additional operational flexibility will be considered to obtain additional benefits, and to provide the opportunity to minimize impacts in the longer term. For instance, past experience shows that low volume releases carried out in a pro-active manner can reduce the later need for more potentially damaging high volume releases to the estuaries, and also reduce littoral zone impacts due to rapidly rising stages. The additional operational flexibility is expected to provide benefits to a variety of fish, wildlife, and aquatic plants, both in the lake and in downstream ecosystems.

Once implemented, releases will be discontinued when the conditions that prompted them have ceased or the desired outcome is achieved. Based upon the evaluation of historical conditions and the expected performance of the Preferred Alternative, it is anticipated that use of additional operational flexibility will be infrequent.

Each event to be addressed by additional operational flexibility is unique and releases to be implemented will be defined by a desired outcome or time-period. The public will be notified of the planned releases, desired outcome, and implementation time period by the USACE's normal water management notification process (press release, internet webpage). The following sections identify the scenarios that would trigger the use of additional operational flexibility and provide details on releases to be considered under each scenario. Additionally, the environmental effects for each situation have been considered. The Additional operational flexibility will be used to address circumstances which were not evaluated in the Preferred Alternative POR, such as the following:

a. Undesirable/Prolonged High Lake Levels

Releases may be considered to prevent anticipated high lake levels or to lower high lake levels, in order to reduce risk to the HHD and to prevent additional adverse environmental impacts to Lake Okeechobee. In 2003, continuous high lake levels (above 15 ft., NGVD in excess of 13 months) resulted in a Temporary Deviation. The purpose of this Temporary Deviation was to minimize the risk of high lake levels, to lower Lake Okeechobee for prevention of additional adverse impacts in the lake and to reduce the potential of high-volume continuous releases to the estuaries. These intended purposes were accomplished while balancing other management objectives of water supply and flood control.

In the event that there are ongoing or planned activities at C&SF Project features (including CERP Projects) upstream or downstream of Lake Okeechobee, and high lake levels are projected to occur or anticipated to occur as a result of these activities and based on any combination of planned water management operations, climate forecasts, and historical information/data, then additional releases to the WCAs and to tide (estuaries) could be considered. All project purposes will be considered. When possible, the lake releases to tide (estuaries) would be limited to a pulse release from Lake Okeechobee not to exceed 2800 cfs measured at S-79 and 2000 cfs measured at the St. Lucie Estuary. This includes releases from all C&SF Project structures that discharge into the St Lucie Estuary. Releases to the WCAs would depend on available treatment capacity in the STAs.

Additional releases might be implemented to lower Lake Okeechobee's level in advance of planned activities and/or to prevent high lake levels. An example is a planned muck removal operation involving a lake drawdown in the Kissimmee River Basin that could result in the need to create storage in Lake Okeechobee prior to the planned Kissimmee River Basin drawdown.

b. Climate Conditions

In the event that climate conditions including but not limited to, El Nino, La Nina, and/or active hurricane season forecasts are projected to create or continue high lake levels, additional operational flexibility would allow releases to WCAs and to tide (estuaries) to be implemented. The lake releases to tide (estuaries) should be limited to a pulse release from Lake Okeechobee not to exceed 2800 cfs measured at S-79 and 2000 cfs measured at the St. Lucie Estuary. This includes releases from all C&SF Project structures that discharge into the St Lucie Estuary. The wet spring of 2004 (normally the dry season) and an overly active hurricane season are examples of conditions that could be addressed with additional operational flexibility.

c. Low Volume Releases

In the event that the lake level is above the Water Shortage Management Band and conditions exist that would require low-volume releases, additional operational flexibility

would allow low-volume releases to be implemented. The low-volume releases would be implemented to address conditions including, but not limited to the following: to prevent and/or to lower high lake levels, to address algal blooms, to disperse saltwater in the river and/or estuary, or improve other conditions related to the Congressionally-authorized project purposes. The proposed low-volume releases would be limited to a pulse release from Lake Okeechobee of up to 2000 cfs measured at S-79 and up to 730 cfs measured at S-80.

As an example, a Low Volume Release operation occurred in 2004. Operations were conducted that included a pulse release that averaged up to 1600 cfs to the Caloosahatchee Estuary and up to 730 cfs measured at S-80. The purpose of these operations was to minimize the risk of high lake levels, to lower Lake Okeechobee for prevention of additional adverse impacts in the lake and to reduce the potential of high constant releases to the estuaries. These intended purposes were accomplished while balancing other management objectives of water supply and flood control. The effects of such releases are displayed in Table 3-1.

TABLE 3-1: EFFECTS OF RELEASES ON LAKE OKEECHOBEE WATER LEVEL**Effects of Beneficial Use Sub-band Releases on Lake Okeechobee Water Level**

Lake Okeechobee Release (average daily cfs)	Lake Okeechobee Release		Lake Okeechobee Release	
	Duration (days)	Effect on Lake Okeechobee (feet) ¹	Duration (days)	Effect on Lake Okeechobee (feet) ¹
200	1	0.001	20	0.023
300	1	0.002	20	0.035
400	1	0.002	20	0.046
500	1	0.003	20	0.058
600	1	0.003	20	0.070
700	1	0.004	20	0.081
800	1	0.005	20	0.093
900	1	0.005	20	0.104
1000	1	0.006	20	0.116
1100	1	0.006	20	0.128
1200	1	0.007	20	0.139
1300	1	0.008	20	0.151
1400	1	0.008	20	0.162
1500	1	0.009	20	0.174
1600	1	0.009	20	0.186
1700	1	0.010	20	0.197
1800	1	0.010	20	0.209
1900	1	0.011	20	0.220
2000	1	0.012	20	0.232
2100	1	0.012	20	0.244
2200	1	0.013	20	0.255
2300	1	0.013	20	0.267
2400	1	0.014	20	0.278
2500	1	0.014	20	0.290
2600	1	0.015	20	0.301
2700	1	0.016	20	0.313
2800	1	0.016	20	0.325

1 Effect on Lake Okeechobee based on lake storage change from elevation 10.5 ft. to 11.5 ft. (341,500 acre-feet)

Effects of evapotranspiration on Lake Okeechobee Water Level

Month	Evapotranspiration		Evapotranspiration	
	Duration (days)	Effect on Lake Okeechobee (feet) ²	Duration (days)	Effect on Lake Okeechobee (feet)
January	1	0.006	20	0.120
February	1	0.008	20	0.160
March	1	0.011	20	0.220
April	1	0.012	20	0.240
May	1	0.013	20	0.260
June	1	0.012	20	0.240
July	1	0.011	20	0.220
August	1	0.01	20	0.200
September	1	0.009	20	0.180
October	1	0.009	20	0.180
November	1	0.007	20	0.140
December	1	0.006	20	0.120

2 From the Drought Contingency Plan contained in Lake Okeechobee EAA Water Control Manual

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4. EVALUATION TOOLS

4.1. MODELING

What is the South Florida Water Management Model?

The SFWMM was the tool used to evaluate all LORSS alternatives. The SFWMM is a regional-scale computer model that simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7600 square miles using a mesh of two mile by two (2x2) mile cells. In addition, the model includes inflows from Kissimmee River, and runoff and demands in the Caloosahatchee River and St. Lucie canal basins. The model simulates the major components of the hydrologic cycle in south Florida including rainfall, evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, levee seepage and groundwater pumping. It incorporates current or proposed water management control structures and current or proposed operational rules. The ability to simulate water shortage policies affecting urban, agricultural, and environmental water uses in South Florida is a major strength of this model. The SFWMM simulates hydrology on a daily basis using climatic data for the 1965-1995 period which includes many droughts and wet periods. For the current LORSS, the SFWMM v5.5 was used, which added an additional five years of climatic data from 1996-2000. The model was calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. Technical staffs of many federal/state/local agencies and public/private interest groups have accepted the SFWMM as the best available tool for analyzing regional-scale structural and/or operational changes to the complex water management system in south Florida.

Why is the SFWMM needed?

The hydrology of south Florida is unique due to the flat topography, high water table, sandy soils, and high conductivity of the aquifer system. With the rapid population growth in south Florida, the water control system has been expanded and its operation has become increasingly complex, making the southern Florida water management system one of the most complex in the world. Currently, federal/state/local agencies are involved in numerous environmental restoration and water resources development projects that are necessary to sustain the quality of life in this rapidly growing region. These projects can potentially cost billions of dollars and accurate determination of their benefits and costs is extremely important. Simulation models have become the only feasible means of assessing system-wide impacts of the various proposed modifications to the water resources system in south Florida. The SFWMM, developed specifically for the south Florida system, is currently the best available tool that can simulate the complexities of the water control system and operational rules of proposed regional-scale water management alternatives and provide adequate information for making water management decisions.

4.2. PERIOD OF SIMULATION

The SFWMM produces daily output for a 36-year period of record (POR), 1965-2000. Efforts are ongoing by the SFWMD to compile the climatological data needed to extend the SFWMM POR through 2005. The additional information, though desirable, was not available for the current LORSS. However, the Preferred Alternative was simulated for the 2001 through 2005 period using the LOOPS, and the preferred alternative was deemed effective for managing high lake elevations under this set of conditions. For informational purposes, a summary of the LOOPS hydrologic output is provided in Appendix E.

4.3. PERFORMANCE MEASURES

All alternatives were evaluated against a set of performance measures. CERP based performance measures were used for Lake Okeechobee ecology, the estuaries and greater Everglades while public safety, navigation and water supply were developed with input from the LORSS PDT. In-depth documentation and rationale for the CERP based performance measures is available through the Restoration Coordination and Verification (RECOVER) performance measure documentation in the draft RECOVER CERP System-wide performance measures report (RECOVER, 2006), at the following web address:www.evergladesplan.org/pm/recover/eval_team_perf_measures.cfm.

4.3.1. LAKE OKEECHOBEE ECOLOGY

The performance measures for Lake Okeechobee: extreme low lake stage, Lake Okeechobee extreme high lake stage, and Lake Okeechobee stage envelope, were utilized to evaluate the alternatives of the LORSS effort.

Extreme low and extreme high lake stage are evaluated with response curves. For extreme low lake stage, zero weeks below ten feet, elevation NGVD responds to a score of 100, and 540 weeks or greater with stages below ten feet responds to a worst case situation (15 weeks per year over 36 year simulation period), with scores linearly varied between the two extremes. For extreme high lake stage, zero weeks above 17 feet elevation NGVD responds to a score of 100 and 396 weeks or greater with stages above 17 weeks responds to the assumed worst case situation (11 weeks per year), with scores linearly varied between the two extremes.

The stage envelope performance measures similarly documents the benefits of seasonally-variable water levels within the range of 12.5 feet (June-July low) and 15.5 feet (November-January high) on the plant and animal communities of Lake Okeechobee. The conceptualization of the optimal stage envelope seasonal variation is shown in Figure C-11 of Appendix E (the comparison actually utilizes smoothed boundaries for the upper and lower envelope); in simplified terms, penalty points are assigned to each alternative based on deviations outside of the envelope, with increased penalty points with increased distance away from the optimal envelope. The worst case scenario for variability above the stage envelope is assumed to be one where the lake stage hydrograph is always in the poor zone (1.0 foot outside of the stage envelope), which equates to a total score of 1872 foot-weeks; the response curve

is a line between 0 (target, score of 100) and 1872 foot-weeks (score of 0). For deviation of lake stage below the envelope, the target is 192 weeks. This is the score that would be obtained if all years had hydrographs within the optimal zone, except for once per decade the stage falling to just below 11 feet elevation for an average of three months. The response curve is a line between 192 (192 foot-weeks or less receives a score of 100) and 1872 foot-weeks (worst case scenario receives a score of zero).

4.3.2. NORTHERN ESTUARIES

High volume releases to the estuaries generally occur during the wet season. During the dry season (mid-November to mid-May), high volume releases are usually infrequent.

To evaluate the various alternatives, three PMs were examined for the Caloosahatchee and St. Lucie estuaries: the number of mean monthly flows in various flow ranges over the 36 year POR (POR equates to 432 months), a duration measure based on the weekly moving average discharge at S-79 for the Caloosahatchee; the two-week moving average total discharge to the St. Lucie; and finally the number of mean monthly flows in various flow ranges during the critical spring spawning period.

The PM used for the Lake Worth Lagoon was based on the RECOVER hydrologic PMs for the Central Zone of the Lake Worth Lagoon, which is based on the salinity tolerances of oysters (*Crassostrea virginica*).

It is important to note that the hydrologic model output assumes maximum practicable releases from Lake Okeechobee within each decision tree band, with consideration of downstream operational constraints. This provides a very useful means for comparing the effects of all alternatives. However, the decision making process to determine quantity, timing, and duration of the potential release considers estuary conditions/needs, potential impacts from lake releases, local runoff, and dry weather conditions. Although modeled and represented in the modeling output, maximum releases are not always necessary or recommended.

CALOOSAHATCHEE ESTUARY

For the LORSS, estuarine scientists provided input to gauge estuary performance. Estuary PMs were quantified in terms of occurrences and duration of critical inflows from the W.P. Franklin Lock and Dam structure (S-79), which demarcates the beginning of the estuary, and acts as a barrier to salinity and tidal action. Too much salt in the upper estuary may adversely impact the brackish water organisms that normally inhabit this region. Since maintaining an optimal salinity regime in the estuary is an important factor, the PMs used were based on freshwater discharges from the Caloosahatchee River (C-43 canal) at the S-79 structure.

During the driest times, a mean monthly flow of 450 cfs at S-79 is required to maintain viable salinity conditions in the upper estuary. To assist the estuary in receiving this low volume release, all of the alternatives, except the No Action Alternative, would provide environmental base flow releases to the Caloosahatchee Estuary. This feature was

included to address the dry season inflows that may be too low to maintain a viable salinity gradient in the estuary. This is critical for the estuary because during times of extended low inflow conditions, when salinity is too high in the upper estuary, tape grass (*Vallisneria americana*), which is a salt tolerant, fresh water species, becomes very sparse and can disappear completely (Doering et al., 2002).

For the Caloosahatchee Estuary, flows between 450 cfs and 2800 cfs sustain an ecologically appropriate range of salinity conditions in the estuary. These flow targets include Lake Okeechobee releases combined with basin runoff. Flows greater than 2800 cfs are considered by estuarine scientists as being high for the Caloosahatchee Estuary. High flows in this range can cause salinity to fall below the tolerance range of many organisms living in the more marine lower estuary. Prolonged flows of 4500 cfs are considered more undesirable as salinity is depressed in San Carlos Bay which may cause adverse effects to seagrasses and other organisms in this region. High flows greater than (>)2800 cfs in the Caloosahatchee Estuary may prevent the early life stages of fish, shellfish and other commercially and recreationally important species from utilizing estuarine habitat. Alternatives with the fewest number of mean monthly flows exceeding 2800 cfs are preferred.

ST. LUCIE ESTUARY

The natural shoreline and inter-tidal areas of the estuary were once populated by mangroves, SAV, and oyster beds but now due to shoreline alterations and salinity alterations supports very little vegetation. Most SAV coverage in the St. Lucie is now found only near the Indian River Lagoon, or St. Lucie Inlet. However, the American Oyster (*Crassostrea virginica*) does still inhabit the estuary. Maintaining the correct salinity in the estuary allows oyster bars to persist and flourish.

A preferred flow envelope (350 cfs -2000 cfs) has been established for the St. Lucie estuary. These guidelines defined 350 cfs mean monthly total flow from the watershed as the minimum flow target that created the highest salinity gradient and a 2000 cfs maximum inflow target that created the lowest preferred salinity gradient (a salinity of about eight parts per thousand [ppt] at the Roosevelt Bridge). The lowest preferred salinity was based primarily on the lower salinity physiological tolerances of the American oyster, which historically flourished in the mid estuary before major drainage infrastructure was constructed in the watershed. Accordingly, if inflows from groundwater and surface water runoff to the inner estuary exceeded about 2000 cfs, salinity in the mid estuary will cause significant stress and a high probability of oyster mortality.

The low flow target for the St. Lucie Estuary was originally based on groundwater and not on high salinity tolerances of the American oyster, since they can spawn and grow rapidly in seawater. The minimum total flow target for the inner estuary was based on the amount of groundwater it receives with present watershed hydrology (Haunert and Konyha 2004). While the low target is not directly based on oyster salinity tolerance, salinities associated with these flows (25 ppt at the Roosevelt Bridge) would expose oysters to a greater risk of mortality from predators and parasites.

Hydrologic PMs used for the St. Lucie were: 1) distribution of mean monthly flows for the entire POR; 2) mean monthly flows during the critical period (March–June) when many estuarine dependent species reproduce; 3) duration of high flows. Mean monthly total inflows to the St. Lucie Estuary were divided into flow classes based on the RECOVER PMs.

Mean monthly total inflows in the 2000–3000 cfs range result in low salinities throughout the estuary. Flows greater than 3000 cfs may begin to impact more marine water in the Indian River Lagoon. The longer durations of high-flow releases (consecutive two-week periods with a 14-day average flow >3000) are of concern for protecting aquatic resources, including oysters and SAV. Minimizing flows >2000 cfs would provide a salinity range more favorable to oysters and downstream SAV.

LAKE WORTH LAGOON

The RECOVER hydrologic PMs for the Central Zone of the Lake Worth Lagoon are based on the salinity tolerances of oysters (*Crassostrea virginica*). A minimum salinity target of 15 ppt was chosen because this is a mid-range salinity that meets the requirements of all life stages. Discharges into the Central Zone of 500 cfs or less will maintain salinity at or above the 15 ppt minimum. A seven-day moving average is used to quantify flow. To reflect deleterious effects of very high discharges (>1000 cfs) a two-day moving average is employed to calculate target inflows.

4.3.3. WATER CONSERVATION AREAS (GREATER EVERGLADES)

Indicator Regions (IRs) representing a variety of habitat types in the Everglades were used to evaluate the alternatives. The Indicator Regions represent areas of the major ecosystems with differing hydrologic and ecological conditions, ranging from the southern end of the EAA through the WCAs to the southern tip of the ENP (see Figure 1). For Peat Dry-Out, Tree Islands, and Snail Kite Habitat Performance Measures, the Indicator Regions located within the WCAs and ENP were used (33 total IRs: 100-102, 110-126, 128-133, 140, 141, 143, 147, 148, 160, and 170). For Recessions and Reversals, only the Indicator Regions within the conservation areas were used (IRs 100-102, 110-126, 128, and 129).

Hydrologic Performance Measures were used in these analyses to evaluate impacts of the Alternatives on the Everglades. Water quality was not evaluated. The Everglades hydrologic Performance Measures were 1) peat dry-out, 2) tree island inundation, 3) wading bird breeding season water recession rates, 4) wading bird breeding season water reversals, and 5) Snail Kite habitat (breeding and Apple Snail reproduction).

The primary inflow to the Greater Everglades other than precipitation is from STA-3/4. This STA filters Lake Okeechobee water and EAA runoff, the total volume of which is constrained by water quality. Model assumptions regarding this inflow were consistent between simulations, so few differences would be expected between these alternatives. In actual operations, the treatment capacity constraint for STA-3/4 would be an annual constant for the No Action Alternative and all alternatives, and the volume and timing of releases south would not be expected to change.

Peat dry-out, total weeks: Peatlands require constant inundation in order to be sustainable. They form under constant inundation so constant saturation is essential to their existence. In addition to damaging the ecosystem, peat dry-out increases the frequency and severity of peat fires, which cause even more damage to the wetlands. Peat fires differ from surface fires, from which vegetation recovers quickly. Peat fires eliminate plant roots and the peat. Evaluation is based upon the sum of the number of weeks (in all Indicator Regions) that water depths were -1 foot or more below the surface. The target is to reduce the weeks of very low water tables to reduce the risk of peat fires and related damage to the peat.

Wading Bird Nesting Success: Wading birds nest from January through May in the Everglades. The two performance measures that address wading bird nesting in the WCAs are hydrologic recession rates and reversals. Recession rates are the declines in water depths during the dry season whereas Reversals are increases in water depths during this same period.

Recessions: As water depths decline in the dry season, wading bird food species are concentrated in the shallower water, increasing the wading birds' feeding efficiency. Optimal water depths for wading birds vary by species; the birds move across the landscape to areas of preferred water depths as water levels decline. Concentration of prey as water levels drop allows the parent birds to feed their hatchlings and to successfully fledge the year's young.

Target recession rates are a decrease of -0.1 foot per week ("good is -0.05' to -0.16' per week). Model output reports the average number of weeks that recession rates fall into this "good" category, and the goal is to increase the percent of these preferred weekly recession rates during the wading bird breeding season.

Reversals: When water levels rise during the breeding bird season (January through May), food prey that was concentrated in shallower pools disperses, reducing feeding efficiencies of the parent birds. When parent birds find less food, their nesting success is poorer, so reversals should be avoided during this period of the year. This performance measure averages the percent of weeks of reversals (when recession rates are above -0.04' per week). Lower numbers are better.

Tree island inundation: As wetland species, trees on tree islands are accustomed to long periods of inundation. However, excessive inundation can reduce the survival of tree species, particularly when excess inundation periods occur several years in a row. The Tree Island Inundation Performance Measure records the duration in weeks (summed over all Indicator Regions) of water depths above 1.5', 1.75', 2.0', or 2.5', depending on the specific area of the Everglades (high water depth criteria for Indicator Regions 115, 116, 140, 141, 148 are 2.0'; for IRs 143 and 147 are 1.5'; for IRs 160 and 170 are 1.75'; and all others are 2.5'). Inundation should not exceed 17 weeks per year.

Greater Everglades Snail Kite: Snail Kites reproduce from approximately February 15 through May 15 each year, and they feed upon Apple Snails. Rapid water level increases during this period drown Apple Snail eggs, and loss of a year's cohort of Apple Snail eggs reduces their populations for two to three years. Snail Kite reproduction and survival, which rely on these snail populations, are also harmed by loss of Apple Snails.

The Performance Measure for the Snail Kites identifies "Optimal" (O) conditions, "Marginal" (M) conditions, and "Unsustainable" (U) habitat conditions for Snail Kites. For the Indicator Regions, changes in ratings were valued as 0 for unchanged, 1 or 2 for improvement (one category or two categories of improvement), and -1 or -2 similarly for declines. These values are summed over the Indicator Regions to indicate Greater Everglades habitat suitability under the alternatives.

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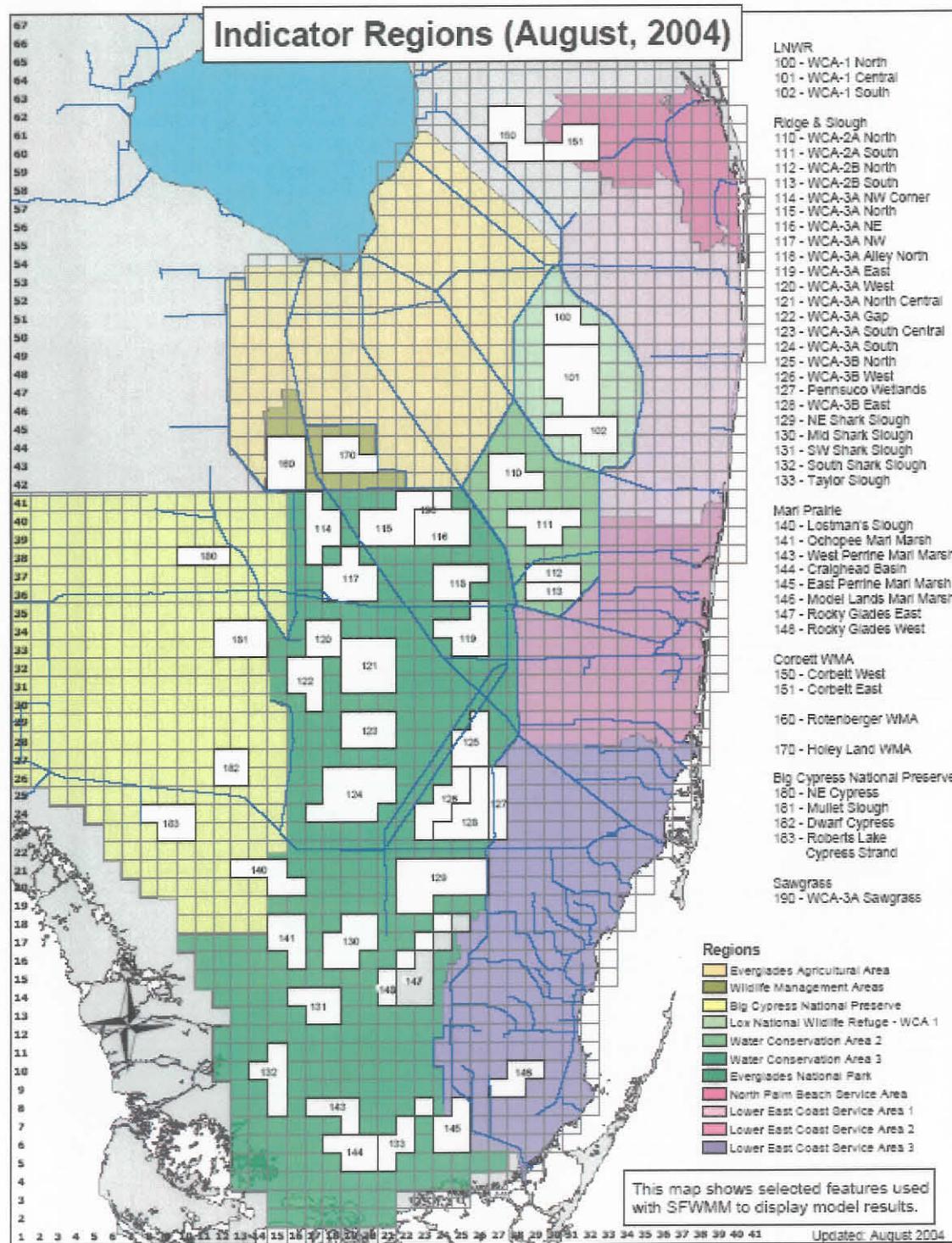


FIGURE 4-1: GREATER EVERGLADES INDICATOR REGION

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4.3.4. WATER SUPPLY

Several PMs were used to compare the potential water supply impacts of the alternatives. The water supply PMs are rooted in and include the Lake Okeechobee Service Area (LOSA) water supply PMs promulgated and used by RECOVER for CERP system wide evaluations. These PMs reflect the CERP water supply goals which are to:

- Provide at least a 1-in-10 level of service as indicated by simulations using the South Florida Water Management Model (SFWMM) in which three or less water years in the 36-year simulation period have water shortages in which significant water supply cutbacks are necessary.
- Additionally, the performance targets are to minimize the severity and duration of any water restrictions over and above those that might be expected when drought levels exceed a 1-in-10 severity.

The frequency, duration and severity measures used match the RECOVER measures for LOSA. In addition a measure has been included which is based on the frequency of water shortages in LEC Coastal Basins but focuses only on the impact of Lake Okeechobee conditions on the frequency of these shortages (assuming there are no locally triggered coastal basin shortages).

Other measures have been included which present percent of demands not met, total demands not met during a simulation and number of times demands not met in a water year exceeded 100,000 and 200,000 acre-feet. These measures help to round out and present a clearer and more robust picture of the effects of the shortages. Ranking of alternatives are generally not changed by considering these measures in addition to those from RECOVER.

The following PMs were evaluated in this SEIS:

- Additional Supply Side Management Cutbacks (acre-feet)
- Frequency of Water Shortages (years)
- Duration of Water Shortages (months)
- Severity of water shortages score
- Water years with SSM cutbacks >100,000 acre-feet
- Water years with SSM cutbacks >200,000 acre-feet
- EAA percent of Demands not met
- Other LOSA percent of Demands not met
- Coastal Basin Supply Side Management water shortages

4.3.5. HERBERT HOOVER DIKE

One of the goals of the LORSS is to reduce the frequency of high lake stages that may be stressful to the HHD levee system surrounding Lake Okeechobee, which provides flood protection for the surrounding area. Lake Okeechobee water levels are managed

to minimize risks for each hurricane season. Issues such as seepage, piping, and boils are exacerbated when the lake elevation approaches 18.5 ft., NGVD (USACE, 2005), which is the maximum release elevation of the current schedule, WSE. For the current LORSS, a main objective was to look at ways to develop an alternative schedule that lowers the maximum release trigger for flood protection purposes. As such, a PM for flood protection was developed. The PM was selected to formulate releases that minimized lake elevation >17.25 ft. NGVD. Operationally, this means that at elevation 17.25 ft. NGVD, maximum lake releases would be made east, west and south, in an attempt to lower the high lake levels. The reason for selecting elevation 17.25 ft. NGVD as the PM elevation was to address the numerous factors that generate uncertainty in the rate of rise on the lake primarily during the rainy season. This elevation would be used as a predictive buffer against Lake Okeechobee rising to an unacceptable high elevation that could compromise the integrity of the HHD and could result in a breach of the levee.

4.3.6. NAVIGATION

The hydrologic PM used for navigation was based on the 1965-2000 simulation POR. The performance of each alternative was measured by the number of times in the POR that lake stage is below 12.56 feet.

4.4. EVALUATION OF WATER SHORTAGE MANAGEMENT ASSUMPTIONS

Concurrent with the 2007 LORSS draft SEIS, the SFWMD is in the process of examining its current water shortage rules in Chapter s 40E-21 and 40-E22. The SFWMD water shortage rules provide the framework of when and to what extent low lake levels will trigger water shortage cutbacks. Modification of the water shortage rules is important as the Preferred Alternative model run projects lower lake levels more often than the existing WSE schedule.

During the plan formulation period of this revised draft SEIS, the SFWMD provided the Corps with their new proposed water shortage rules as described in the LOWSM Plan (Appendix G., Attachment 1). The 2006 draft LOWSM plan is included in the modeling assumptions and evaluations provided in Appendix E. Based on guidance from SFWMD during the 2007 revised draft SEIS plan formulation phase, the 2006 draft LOWSM plan was not anticipated to undergo significant change prior to approval by the SFWMD Governing Board later in 2007. As a result, the LOWSM was used as a basis for incorporating water shortage assumptions in the Alternatives model runs.

Since the evaluation of the alternative model runs, the SFWMD rule development process has produced a significant amount of public and stakeholder input on the newly proposed lake management methodologies. This input includes significant concerns of low lake levels, including increases in the potential for Lake Okeechobee minimum flow and level (MFL) exceedances, which occur under the proposed LORS changes. In particular there was concern that Phase I and II cutbacks under the LOWSM proposal would not be triggered until the lake levels fell below 11 feet NGVD. In recognition that the existing lake MFL is based on the amount of time the lake remains below 11 feet NGVD, requests were made to implement the phased cutbacks prior to reaching that

level. Rules pertaining to the MFL's are found in the Florida Administrative Code, Chapter 40E-8.221(1). MFL information can also be accessed at www.sfwmd.gov. The SFWMD suspended rule making on the LOWSM plan in May 2007 and informed the USACE that the SFWMD may not be able to revise the LOWSM trigger line below the current SSM trigger.

In May 2007, the USACE was preparing to release the LORSS revised draft SEIS for public review and comment. In response to the SFWMD suspension of the LOWSM rule making process, the USACE conducted modeling analysis to quantify the potential effect on water supply performance if no change to the existing SSM trigger line was made. The range of potential water supply performance between the existing SSM trigger line and the SFWMD refined LOWSM plan (assumed in place for Alternative A through E presented and evaluated in this report) was bracketed and included in USACE water supply performance evaluation of this LORSS revised draft SEIS. A comparison of the simulated water supply performance for the No Action Alternative, the Preferred Alternative with LOWSM, and the Preferred Alternative with Existing Water Shortage Triggers (WST) is provided in Section 6.12.1. The Preferred Alternative with existing WST simulation provides information on the implications if the SFWMD implements water shortage restrictions under its current rules (assumes no changes to the current SFWMD Water Shortage Plan in response to the LORSS proposed modifications to the LORS).

4.4.1. LOWSM EFFORTS CONCURRENT WITH THE LORSS FINAL SEIS PREPARATION

Coincident with the release of the LORSS revised draft (June 2007) SEIS, the LOSA was being subjected to water shortage restrictions as the stage of the Lake fell within the Zone A water shortage area as described in SFWMD Rule (40E-22, 40E-21 F.A.C.). Working with the SFWMD Governing Board and stakeholders, the SFWMD imposed water shortage cutbacks consistent with the 2001 rule but based on crop demands as they occur during a 1 in 10 level drought (as opposed to average rainfall assumed conditions) and consistent with the SFWMD MFL criteria. The SFWMD held its last scheduled rule workshop in late summer, 2007. This workshop introduced a rule concept which reflected management of the Lake during the 2007 drought and was consistent with the 2001 version of the rule and the Lake's MFL criteria. The water shortage rule imposes more significant water restrictions earlier on through LOSA (compared to the existing water shortage management plan established in 2001). This proposal was supported by stakeholders and was presented to the SFWMD Governing Board for authority to publish the rule and adopt the rule, if no public hearing was requested. Because no hearing was requested by October 19, 2007 the rule is expected to be effective November 15, 2007. SFWMD's Notice of Proposed Rule for Lake Okeechobee Water Shortage is provided as Attachment 2 of Appendix G.

Though operational details for implementation have not been finalized by the SFWMD and provided to the Corps in time for publication in the LORS Final SEIS, the water shortage rule is expected to provide water supply performance within the bracketed range that was evaluated in the LORSS revised draft SEIS. Water supply performance

is expected to fall closer to the evaluation provided for the existing water shortage rules than to the performance with the LOWSM. The Water Control Plan will be finalized with effects within the bracketed range for water supply performance documented in this EIS. Changes to the Water Control Plan to reflect any modifications by the SFWMD to its water shortage management rules can be accommodated under this analysis so long as the SFWMD can demonstrate they do not result in impacts outside the bracketed performance range.

4.5. ANALYSIS COMPLETED FOR INFORMATIONAL PURPOSES ONLY: NOT A FEDERAL ACTION

Section 4.5.1 and 4.5.2 are provided for informational purposes, and are not Federal actions. As such, these actions have not been considered in the alternative analysis and effects evaluation as required by the NEPA.

4.5.1. STORAGE OF LAKE WATER ON PUBLIC/PRIVATE LANDS

In January 2007, the SFWMD Governing Board passed a resolution requesting the Corps to take into consideration increased storage capacity on public and private lands in the Okeechobee Watershed to receive Lake Okeechobee water releases. A copy of the resolution letter is provided in Appendix H. The SFWMD lands for water storage would be utilized to achieve a more refined balance between the competing needs of Lake Okeechobee and estuarine ecosystems, flood control, and water supply. The Corps is strongly supportive of this initiative and continues to work with SFWMD on ways to proceed with the action. The analysis described in this section demonstrates potential benefits that could be realized from utilization of the SFWMD lands for water storage to receive Lake Okeechobee water releases.

The SFWMD proposal to allow water storage on SFWMD public and private lands has the potential to reduce the frequency of high volume flow releases to the Caloosahatchee and St. Lucie estuaries from the conditions presented and evaluated for the 2007 LORSS SEIS preferred alternative (Alternative E). The SFWMM simulation of the 2007 LORSS SEIS preferred alternative does not assume availability of the proposed SFWMD lands for water storage. To provide a quantification of the potential estuarine benefits that could be realized from utilization of the SFWMD lands for water storage, an analysis was completed using the mean monthly flows from the SFWMM simulation of the 2007 LORSS Preferred Alternative. The assumptions and results from this analysis are documented in the remainder of this section.

The SFWMD has stated that 450,000 acre-feet of storage will be available for water storage to attenuate and reduce anticipated high flows to the Caloosahatchee and St. Lucie estuaries. Approximately one-third of this proposed storage volume (150,000 acre-feet) would be available through lands that have currently been identified by the SFWMD, including the Holeyland and Rotenberger WMAs located south of Lake Okeechobee. The locations for the total 450,000 acre-feet storage volume have not been identified by the SFWMD. Conveyance improvements, new water control structures, and impoundment design specifications required for operational utilization of the storage features have not been sufficiently identified for their inclusion in local or

regional hydrologic models. Based on the inability to complete a modeling analysis similar to the SFWMM analysis used to evaluate the suite of alternatives identified in this report, an alternate analysis tool was required to provide a quantification of potential estuarine benefits of the SFWMD storage initiative. A spreadsheet tool was used to analyze the time series for Lake Okeechobee discharges to the Caloosahatchee and St. Lucie estuaries from the SFWMM simulation of the 2007 LORSS Preferred Alternative to provide a general quantification of the potential estuarine benefits from utilization of the SFWMD lands for water storage. The time series data used for this analysis is available on the Corps LORSS modeling web page with the SFWMM standard model output for Alternative E (Alternative T3 is the original simulation name for Alternative E, as referenced during the LORSS modeling and within Appendix E), at the following address: <http://hpm.sfrestore.org/loweb/sfwmm/>.

Several key assumptions were utilized for this analysis, and these assumptions should be fully considered for interpretation of the results. In addition to the documented assumptions intrinsic to the SFWMM modeling tool (presented in Appendix E), the following assumptions are noted for this analysis:

- 2007 LORSS SEIS preferred alternative simulation (Alternative E) mean monthly flows from the SFWMM are used for the analysis;
- SFWMD public lands will be available for water storage, including all necessary conveyance and control infrastructure;
- Storage will be utilized to capture Lake Okeechobee releases when undesirable “high” flows are experienced at the St. Lucie below S-80 and Caloosahatchee at S-79 estuaries. SFWMM mean monthly flows for the 2007 LORSS SEIS preferred alternative will be used to identify months with undesirable high flows to the estuaries (1965-2000 POR). Separate evaluations were conducted assuming capture of Lake Okeechobee releases by SFWMD storage lands when estuaries were simulated to receive extreme high flows (Caloosahatchee River Estuary greater than 4500 cfs, St. Lucie Estuary greater than 3000 cfs) and intermediate high flows (Caloosahatchee River Estuary greater than 2800 cfs, St. Lucie Estuary greater than 2000 cfs);
- Storage lands may be utilized north of Lake Okeechobee, south of Lake Okeechobee, or within the C-43 or C-44 basins, prior to release from Lake Okeechobee to the estuaries. The analysis assumes the water stored does not enter Lake Okeechobee later and is not used for irrigation or any other purpose that would affect the lake stage and trigger additional releases;
- Storage will not be utilized to capture local runoff in the C-43 and C-44 basins, which also contribute to the undesirable “high” flows;
- Storage volumes are available at the start of each water year (October 1 through September 30). If all available storage volume is entirely used during a given water year, the remaining Lake Okeechobee releases will be sent to the estuaries based on the LORSS TSP simulation output (monthly flows are reduced for partial capture of a given monthly flow volume). Water years are adjusted when consecutive “high” flow months extend across two water years, to ensure storage is not unrealistically assumed to be available due to the transition

- to the next water year (ending water year is extended; starting water year is shortened);
- Two potential available storage scenarios are evaluated: 150,000 acre-feet (lands currently identified by SFWMD) and 450,000 acre-feet (stated target of SFWMD);
 - Equal halves of the total available storage volume is assumed available to the Caloosahatchee River Estuary and St. Lucie Estuary for each water year. If all Lake Okeechobee releases during St. Lucie Estuary high flow months are captured during a given water year, the "excess" storage volume is available to reduce Caloosahatchee River Estuary high flow months.

The SFWMM simulation of the 2007 LORSS SEIS Preferred Alternative (Alternative E) does not assume availability of the proposed SFWMD lands for water storage. The proposed storage features and conveyance and control structures that would be required to utilize the storage are not included in the current version of the SFWMM. The SFWMM simulation PMs for Alternative E show the following frequency of high flow months to the Caloosahatchee Estuary (at S-79): 29 months with mean monthly flows greater than 4500 cfs and 64 months with mean monthly flows greater than 2800 cfs. The simulation PMs for Alternative E show the following frequency of high flow months to the St. Lucie Estuary (includes releases from S-80 plus C-23 and C-24 basins): 31 months with mean monthly flows greater than 3000 cfs and 73 months with mean monthly flows greater than 2000 cfs. Local basin runoff from the C-43 basin (between Lake Okeechobee and S-79), C-44 basin (between Lake Okeechobee and S-80), and the C-23 and C-24 basins (inflows to St. Lucie Estuary east of S-80) contribute to the high flows experienced at the Caloosahatchee and St. Lucie estuaries, and these local basin contributions are included in the PMs totals. Local basin runoff volumes are included in the SFWMM simulations. Local basin runoff alone (without any additional contributions from Lake Okeechobee releases) is noted to exceed Caloosahatchee Estuary high flow thresholds with the following frequency: six months with mean monthly flows greater than 4500 cfs and 37 months with mean monthly flows greater than 2800 cfs. Local basin runoff alone is noted to exceed St. Lucie Estuary high flow thresholds with the following frequency: 11 months with mean monthly flows greater than 3000 cfs and 54 months with mean monthly flows greater than 2000 cfs. For months during which estuary high flow thresholds are exceeded by the local runoff volumes, the capture of Lake Okeechobee releases by assumed available SFWMD storage will not be able to eliminate the high flow event simulated to occur at the estuary. The purpose of this analysis is to determine the number of high flow months able to be eliminated by utilization the proposed SFWMD lands to capture (store) releases from Lake Okeechobee, and the inability to completely eliminate all high flow months (due to the local runoff contributions) is recognized with this documentation. Reduction in the number of high flow months would represent an environmental benefit to the estuaries, as documented throughout this revised draft SEIS.

In the previous discussion of analysis assumptions, it was noted that separate evaluations were conducted assuming capture of Lake Okeechobee releases when estuaries were simulated to receive extreme high flows (Caloosahatchee River Estuary

greater than 4500 cfs, St. Lucie Estuary greater than 3000 cfs) and when estuaries were simulated to receive intermediate high flows (Caloosahatchee River Estuary greater than 2800 cfs, St. Lucie Estuary greater than 2000 cfs). The two evaluations are presented separately in the following paragraphs.

The first evaluation assumes capture of Lake Okeechobee releases by SFWMD storage lands when estuaries were simulated to receive extreme high flows: Caloosahatchee River Estuary greater than 4500 cfs and St. Lucie Estuary greater than 3000 cfs. For the scenario with 150,000 acre-feet of available storage, the Caloosahatchee River Estuary number of months greater than 4500 cfs are shown to be reduced by four months (25 months total) and the St. Lucie Estuary number of months greater than 3000 cfs are shown to be reduced by seven months (24 total months). For the scenario with 450,000 acre-feet of available storage, the Caloosahatchee River Estuary number of months greater than 4500 cfs are shown to be reduced by eight months (21 months total) and the St. Lucie Estuary number of months greater than 3000 cfs are shown to be reduced by 13 months (18 total months).

The second evaluation assumes capture of Lake Okeechobee releases by SFWMD storage lands when estuaries were simulated to receive intermediate high flows: Caloosahatchee River Estuary greater than 2800 cfs and St. Lucie Estuary greater than 2000 cfs. For the scenario with 150,000 acre-feet of available storage, the Caloosahatchee River Estuary number of months greater than 2800 cfs are shown to be reduced by six months (58 months total) and the St. Lucie Estuary number of months greater than 2000 cfs are shown to be reduced by seven months (66 total months). For the scenario with 450,000 acre-feet of available storage, the Caloosahatchee River Estuary number of months greater than 2800 cfs are shown to be reduced by seven months (57 months total) and the St. Lucie Estuary number of months greater than 2000 cfs are shown to be reduced by 11 months (62 total months).

Utilization of storage during intermediate high flow events experienced by the estuaries is expected to reduce or eliminate storage availability to capture extreme high flow events that may follow. The scenario with 150,000 acre-feet of available storage used to capture intermediate high flows results in three additional months of flows greater than 4500 cfs (extreme high flow criteria) to the Caloosahatchee River Estuary and one additional month of flows greater than 3000 cfs (extreme high flow criteria) to the St. Lucie Estuary, when compared to the utilization of 150,000 acre-feet of available storage to capture only the extreme high flows. The scenario with 450,000 acre-feet of available storage used to capture intermediate high flows results in two additional months of flows greater than 4500 cfs to the Caloosahatchee River Estuary and one additional month of flows greater than 3000 cfs to the St. Lucie Estuary, when compared to the utilization of 450,000 acre-feet of available storage to capture only the extreme high flows.

The analysis described in this section demonstrates the potential for estuarine benefits, in the form of reduced frequency of high volume flow events, from the utilization of proposed SFWMD lands for water storage. Additional details regarding the quantity

and location of available storage, conveyance and control structures, and operational protocols (including restrictions) are expected to be defined in the future, at which time additional modeling analysis could be completed. The analysis has also demonstrated the need to consider trade-offs associated with timing of storage utilization when developing guidelines for the utilization of SFWMD public lands storage to capture Lake Okeechobee regulatory releases. The analysis has shown potential trade-offs associated with the capture criteria used for Lake Okeechobee releases by presenting separate evaluations for the capture of extreme high flows and intermediate high flows. Similarly, utilization of storage to capture local basin runoff may reduce or eliminate storage availability to capture Lake Okeechobee releases that may follow.

The quantified potential estuarine benefits presented for this analysis are unique to this analysis. Alternate analysis approaches, modified analysis assumptions, or new local or regional modeling efforts may provide additional information to assist in the quantification of the potential benefits from utilization of the proposed SFWMD lands for water storage.

4.5.2. LAKE OKEECHOBEE PERIODIC MANAGED RECESSION

Since Lake Okeechobee has experienced prolonged high water levels with subsequent undesirable effects to the lake's ecosystem, there was discussion during the LORSS to incorporate a managed recession into the Preferred Alternative regulation schedule. While the Corps agrees that a periodic managed recession may be a necessary management action in the future, the likelihood of implementing this action under the new regulation schedule would be minimal. Due to the fact that the new implemented schedule would be interim, and 2006 and 2007 proved to be a natural recession event for Lake Okeechobee, a full NEPA analysis for a managed recession was not conducted for this phase of the LORSS. If the need for a managed recession occurs under the new schedule, an analysis similar to the one in Appendix F would be completed. Appendix F also includes a summary completed by the SFWMD which outlines the high probability of a natural recession occurring under the Preferred Alternative schedule.

4.5.3. MINIMUM FLOWS AND LEVELS FOR LAKE OKEECHOBEE

Florida law requires the water management districts to establish Minimum Flows and Levels (MFLs) for surface waters and aquifers within their jurisdiction (section 373.042(1), Florida Statute). The minimum flow is defined as the "...limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area". The minimum level is defined as the "limit at which further withdrawals would cause significant harm to the water resources of the area". The MFL for Lake Okeechobee is currently defined as: The water level in the lake should not fall below 11 ft. for more than 80 days duration, more often than once every 6 years, on average (SFWMD, 2000). In addition to low water effects on water supply and navigation, adverse effects may also occur to the lake's littoral zone when water levels fall below 11 ft. At this level, much of the littoral zone is dry and can no longer function as habitat for fish and other aquatic species. The Corps has discussed the effects of low water levels for Lake Okeechobee in Section 6.2 and 6.4. Also refer to Table 6-1.

5. AFFECTED ENVIRONMENT

The Affected Environment section succinctly describes the existing environmental resources of the areas that would be affected if any of the alternatives were implemented. This section describes only those environmental resources that are relevant to the decision to be made. It does not describe the entire existing environment, but only those environmental resources that would affect or that would be affected by the alternatives if they were implemented. This section, in conjunction with the description of the No Action Alternative forms the base line conditions for determining the environmental effects of the proposed action and reasonable alternatives.

5.1. GENERAL ENVIRONMENTAL SETTING

Lake Okeechobee is a subtropical lake in south central Florida with a surface area of 730 square miles and an average depth of nine feet. Lake Okeechobee is a major feature of the Kissimmee-Okeechobee-Everglades system, which is a continuous hydrologic system extending from central Florida south to Florida Bay. Lake Okeechobee provides a number of values to society and nature including water supply for agriculture, urban areas and the environment, flood protection, a multi-million dollar sport fishery, and habitat for many birds and animals, including endangered and threatened species. These values of Lake Okeechobee have been threatened in recent decades by excessive phosphorus loading transported by sediment, harmful high water levels, and rapid expansion of exotic plants (USEPA, 2006).

As a result of the lake's shallow depth, wind is a major influence on Lake Okeechobee. Prior to construction of a perimeter dike system, Lake Okeechobee was much larger than it is now, with an extensive wetland littoral zone along the shoreline. Today, Lake Okeechobee is constrained within the HHD, and the littoral zone is much smaller. As a result, when water levels are above 17 ft., NGVD, the entire littoral zone is flooded; leaving minimal habitat for wildlife that requires exposed ground. When water levels are below 11 ft., NGVD, the entire marsh is dry, and not available as habitat for fish or other aquatic life. Lake Okeechobee's littoral zone is characterized by emergent and submerged vegetation covering an area of approximately 150 square miles (25 percent of Lake Okeechobee's surface area), and is primarily located along the western shore of Lake Okeechobee (Havens et al., 1996) (Figure 5-1). The littoral zone is sensitive to nutrient loading and light availability (Havens, et al., 1999). The vegetation and cover types within the Lake Okeechobee region have been greatly altered during the last century. At present, the littoral zone vegetation consists of many native plant species but also consists of many less desirable and invasive and/or exotic species. The invasion of exotic vegetation has impacted the health and productivity of the littoral zone plant community. Anthropogenic disturbances such as altered hydrology and pollution, along with nutrients, can directly and indirectly affect the health of Lake Okeechobee.

The Caloosahatchee River is the major source of freshwater for the Caloosahatchee Estuary. Alterations to the Caloosahatchee River and watershed over the past century have resulted in a major change in freshwater inflow to the estuary. The Caloosahatchee River was originally a shallow, meandering river with headwaters in the proximity of Lake Hicpohee, near Lake Okeechobee. In the early 1900s, a man-made canal was constructed connecting Lake Okeechobee to the Caloosahatchee River. Today, the river extends from Lake Okeechobee to San Carlos Bay. The river now functions as a primary canal (C-43) that conveys both runoff from the Caloosahatchee watershed and releases from Lake Okeechobee. The canal has undergone numerous alterations including channel enlargement, bank stabilization, and a series of three lock and dam structures. The final downstream structure, W.P. Franklin Lock and Dam (S-79), demarcates the beginning of the estuary (Figure 5-2), and acts as a barrier to salinity and tidal action, which historically extended east near the LaBelle area. As a result of hydrological changes to this ecosystem, the timing, distribution, quality, and volume of freshwater entering the estuary from the watershed and Lake Okeechobee has resulted in negative ecological impacts. Despite these impacts, the Caloosahatchee Estuary continues to be an important environmental and economic resource.

Areas in Lake Okeechobee that Support Native Aquatic Plants

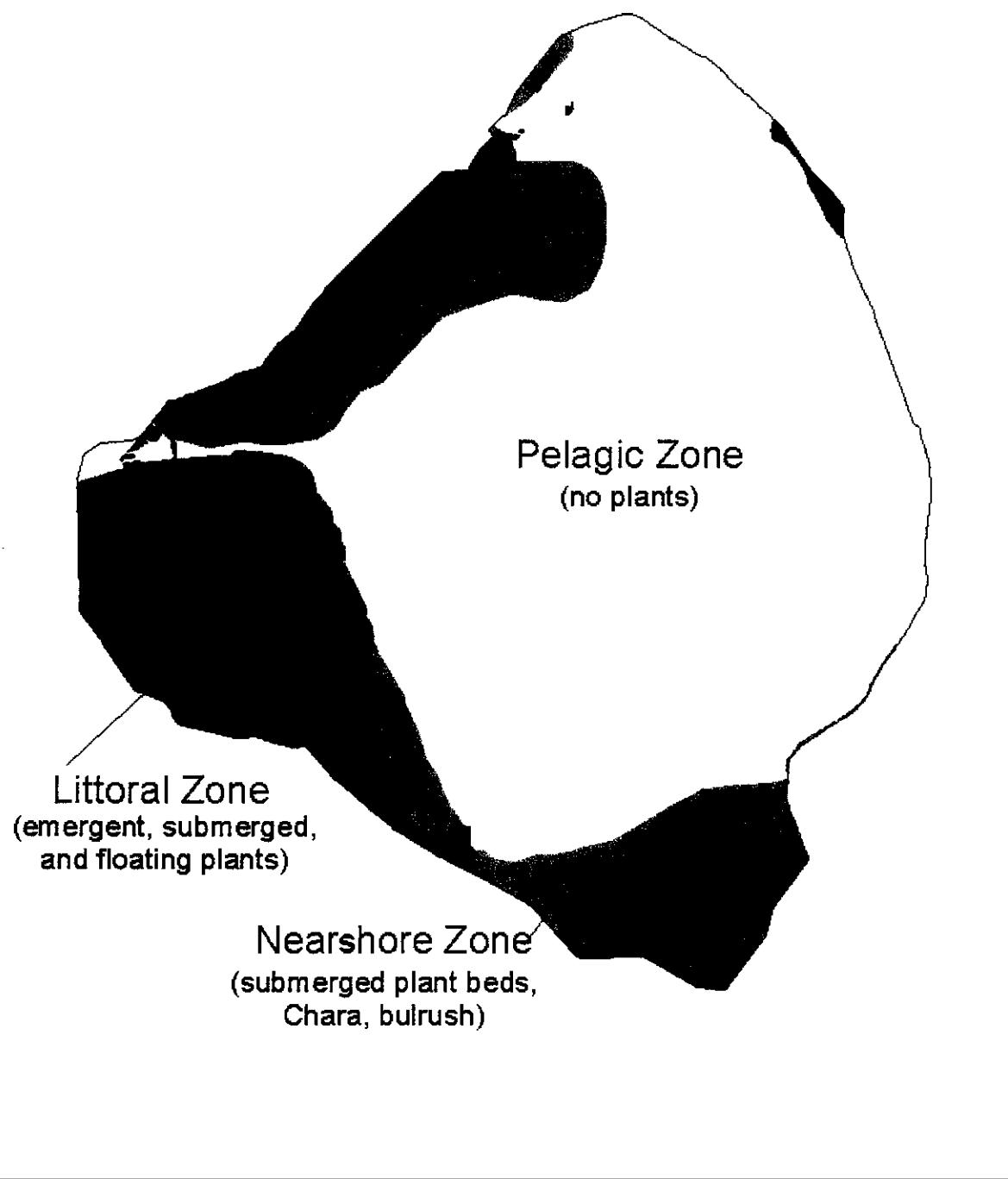


FIGURE 5-1: LAKE OKEECHOBEE ZONES

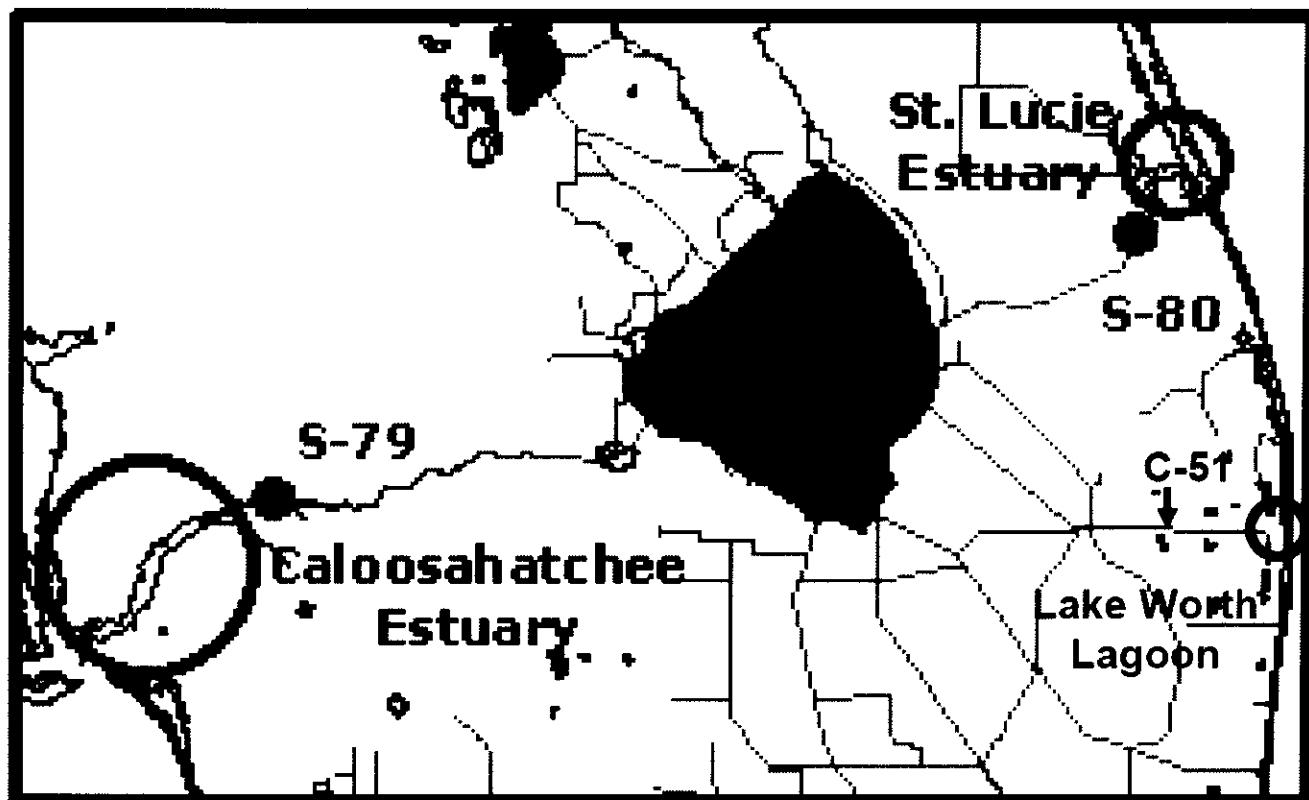


FIGURE 5-2: LOCATION OF ESTUARIES AND STRUCTURES

The St. Lucie Estuary, which is part of the Indian River Lagoon ecosystem, is located on the east coast of Florida (Figure 5-2). The St. Lucie River is approximately 35 miles long and has two major forks, the North and the South, that flow together and then eastward to the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet. Historically, the St. Lucie River system was a freshwater stream flowing into the Indian River Lagoon. An inlet (today referred to as the St. Lucie Inlet) was dug in the late 1800s by local residents to provide direct access to the Atlantic Ocean, thus changing the St. Lucie from a river to an estuary. Then in the early 1900s, the St. Lucie Canal (C-44) was constructed providing an outlet from Lake Okeechobee to the St. Lucie River. The C-44 Canal is used for navigation and releases from Lake Okeechobee. As a result, freshwater flow from C-44 into the estuary tends to be excessive at times, in particular during the wet season, leaving the estuary with too much freshwater. Other major canals constructed in the watershed contributing to fresh water inflow into the estuary include C-23 and C-24 canals. A combination of excessive freshwater inflows, runoff, nutrient loading, and shoreline alterations all contribute to the declining ecological health of the St. Lucie Estuary.

The Lake Worth Lagoon, located in Palm Beach County, is another estuary of importance and evaluated in the LORSS. In size, the Lake Worth Lagoon is the major estuarine water body in Palm Beach County (PBCDERM, 1998). The Lake Worth

Lagoon, centrally located in the county is approximately 20 miles in length, and averages approximately 0.4 miles in width, and six to ten feet in depth (PBDERM, 1998). The Lake Worth Lagoon is separated from the Atlantic Ocean by a barrier island. Historically, Lake Worth Lagoon has been one of the most abused and least protected coastal water bodies in Florida, subjected to much environmental degradation (PBCDERM, 1998). Major freshwater drainage into the estuary occurs from many canal systems. The C-51 canal (Figure 5-2) is the largest inflow of fresh water discharging into the Lake Worth Lagoon (PBCDERM, 1998). The C-51 basin includes the West Palm Beach Canal which extends from Lake Okeechobee south and east to the coastline where it empties into Lake Worth Lagoon. Like most coastal areas in Florida, due to population increase, much of the Lake Worth Lagoon shoreline has been altered. As 65% of the shoreline is currently bulkheaded with only 19% in its original condition, fish and wildlife needs conflict with development and loss of habitat (PBCDERM, 1998).

All of the northern estuary systems are host to plant and animal communities such as seagrass beds, macroalgae, mangroves, oyster bars, birds, fishes, corals, sponges and endangered and threatened species. Additionally, the estuaries attract a variety of commercial, recreational and educational activities such as fishing, boating, ecotourism, and sightseeing.

5.2. VEGETATION

The discussion of vegetation occurring within the study area is organized by physiographic area, beginning with Lake Okeechobee, the estuaries, EAA and concluding with the WCAs. An increased topic of concern is harmful algal blooms (HAB) that occur in the estuaries and Lake Okeechobee. As such, a discussion on algal blooms is presented in this section.

Harmful Algal Blooms

Generally, the proliferation of algae provides the energy source to fuel food webs, so most algae are not harmful even when they form "blooms" that are sometimes seen in coastal, estuarine, and inland waters. However, a small percentage of algae produce toxins, and are termed HAB. HAB occur when algae, simple plants that live in water, produce toxic or harmful effects on people, fish, shellfish, marine mammals and birds. HAB also include blooms of non-toxic species that have harmful effects on marine ecosystems. For example, when masses of algae die and decompose, oxygen can be depleted in the water, causing the water to become low in oxygen. Low oxygen can have adverse effects on marine organisms by forcing them to leave the area, or causing mortality. Two algal groups have traditionally received the dubious distinction of constituting nuisance bloom populations or HAB. They include the prokaryotic cyanobacteria (*Cyanophyceae*, or blue-green algae) and dinoflagellates (*Dinophyceae*).

Perhaps one of the best known HAB is "red tide." Red tides are HABs that occur when microscopic algae in seawater proliferate to higher-than-normal concentrations. The dinoflagellate, *Karenia brevis*, is the most common red tide organism that is responsible for the red tide outbreaks along the southwest coast of Florida. The Florida red tides

occur in the Gulf of Mexico almost every year, generally in the late summer or early fall. Not a new phenomenon, red tide has been documented along Florida's gulf coast since the early 1800s, with anecdotal reports of the effects dating back to the 1500s (FMRI, 2006). Accounts of *Gymnodinium breve* blooms (toxin producing species associated with red tide) were linked with noxious "gases" and massive fish kills along the west coast of Florida as early as 1844 (Tester and Steidinger, 1997). Red tides can adversely affect fish, birds, and marine mammals; cause health problems for humans; and adversely affect local economies (FWRI, 2006). Red tide occurrences are most common off the central and southwestern coast of Florida between Clearwater and Sanibel Island, but may occur anywhere in the Gulf (FWRI, 2006). Red tides may also occur, but are less common, along the southeastern Atlantic coast as far north as North Carolina (FWRI, 2006).

A substantial amount of information has been accumulated through the years as a result of red tide research. The factors that lead to the initiation of a red tide bloom are not well understood; scientists have been monitoring and studying the phenomenon for a number of years. Research does support red tide bloom outbreaks first appearing offshore (Dragovich and Kelly, 1966; Steidinger 1975; Steidinger and Haddad, 1981 as documented by Tester and Steidinger, 1997) and are associated with the fronts caused by the onshore-offshore meanders of the Loop Current water along the outer southwest Florida shelf (Tester and Steidinger, 1997). The role and sources of nutrients involved in initiation and maintenance of a red tide bloom have become a subject of scientific controversy. Several potential sources have been identified: rain, dust, upwelling of deep nutrient rich water, dead fish, other nitrogen fixing algae, submarine ground water discharge and runoff from the land. It is the later source that has focused attention on the role of discharge at the Franklin Lock and Dam (S-79)_on the Caloosahatchee River and releases from Lake Okeechobee. Both have been hypothesized to play a role in both initiation and maintenance. While most scientists agree that runoff could help **maintain** a bloom once it migrates near enough to shore, the generally accepted claim that there is not evidence that runoff from land plays a role in the generation of red tide blooms has been recently challenged (Brand and Compton, 2007). They indicate that nutrients from a combination of non -point source input, river flow and ground water are sufficient to generate and maintain in-shore blooms of red tide. Population increased and other anthropogenic factors have led to significant nutrient enrichment of Florida coastal waters over the past several decades. Whether red tides have increased consequently as suggested by Brand and Compton (2007) is a highly debated topic.

In general, there are a number of physical, chemical, and biotic factors that influence formation of red tides and other HAB (Paerl, 1988) and no single factor has been identified as a root cause. The Northern Estuaries also experience occasional blooms of blue green algae. In some years, these appear associated with discharges from Lake Okeechobee (e.g. Caloosahatchee 2001), while in other years blooms develop during periods with virtually no discharge from the Lake (Caloosahatchee 2006). It is unlikely that discharges from Lake Okeechobee are a prerequisite for HAB formation.

5.2.1. LAKE OKEECHOBEE BASIN

The vegetation and cover types within the Lake Okeechobee region have been greatly altered during the last century. Historically, the natural vegetation was a mix of freshwater marshes, hardwood swamps, cypress swamps, pond apple forests, and pine flatwoods. The freshwater marshes were the predominant cover type throughout, especially along the southern portion of Lake Okeechobee where it flowed into the Everglades. These marshes were vegetated primarily with sawgrass (*Cladium jamaicense*) and scattered clumps of carolina willow (*Salix caroliniana*), sweetbay (*Magnolia virginiana*), and cypress (*Taxodium* sp.). Hardwood swamps dominated by red maple (*Acer rubrum*), sweetbay, and sweet gum (*Liquidambar styraciflua*) occurred in riverine areas feeding Lake Okeechobee, while cypress swamps were found in depressional areas throughout the region. Pine flatwoods composed of slash pine (*Pinus elliottii*), cabbage palm (*Sabal palmetto*), and saw palmetto (*Serenoa repens*) were prevalent in upland areas especially to the north.

Lake Okeechobee has an extensive littoral zone that occupies approximately 150 square miles (about 25 percent) of the lake's surface (Milleson, 1987). Littoral vegetation occurs along much of Lake Okeechobee's perimeter, but is most extensive along the southern and western borders (Milleson 1987). The littoral zone plant community is composed of a mosaic of emergent, submergent and natant plant species. Richardson and Harris (1995) refer to a total of 30 distinguishable vegetative community types in their digital cover map study. Emergent vegetation within the littoral zone is dominated by herbaceous species such as cattail (*Typha* spp.), spike rush (*Eleocharis cellulosa*), and torpedo grass (*Panicum repens*) which is an invasive exotic species. Other emergent vegetation observed includes bulrush (*Scirpus californicus*), sawgrass, pickerelweed (*Pontederia cordata*), duck potato (*Sagittaria* spp.), beakrush (*Rhynchospora tracyi*), wild rice (*Zizania aquatica*), arrowhead (*Sagittaria latifolia*), button bush (*Cephaelanthus occidentalis*), sand cordgrass (*Spartina bakeri*), fuirena (*Fuirena scirpoidea*), rush (*Scirpus cubensis*), southern cutgrass (*Leersia hexandra*), maidencane (*Panicum hemitomon*), white-vine (*Sarcostemma clausum*), dogfennel (*Eupatorium capillifolium*), mikania (*Mikania scandens*). Woody vegetation consist of primrose willow (*Ludwigia peruviana*), Carolina willow, and melaleuca (*Melaleuca quinquenervia*) an invasive exotic species. Over the years, there has been an on-going multi-agency effort to eradicate melaleuca. The eradication effort of melaleuca has been extremely effective.

The submerged vegetation is composed almost entirely of hydrilla (*Hydrilla verticillata*) which is an invasive exotic species, pondweed (*Potamogeton illinoensis*), bladderwort (*Utricularia* spp.), Chara (*Chara* spp.) and vallisneria, also known as wildcelery, eel grass, or tape grass (*Vallisneria americana*).

The natant, or floating, component of the littoral zone consists of lotus lily (*Nelumbo lutea*), fragrant water lily (*Nymphaea odorata* and *N. mexicana*), water hyacinth (*Eichhornia crassipes*) which is an invasive exotic species, water lettuce (*Pistia stratiotes*), duckweed (*Lemna* sp.), coinwort (*Hydrocotyle umbellata*), and ludwigia (*Ludwigia leptocarpa*).

Hydrilla is one of several problem species which occur on Lake Okeechobee. Although it provides good fish habitat, its prolific growth, as evidenced in Fisheating Bay in the mid 1990s, causes navigation and water quality problems. A significant expansion of cattail in the littoral zone has also been observed.

Melaleuca, a resilient species found in a variety of habitats, is one of the principal species of concern on Lake Okeechobee. Melaleuca is capable of displacing native vegetation, including sawgrass marsh (Laroche and Ferriter, 1992), and has been observed to displace native species in other marsh types, cypress-hardwood forests, and pine savanna (Schmitz and Hofstetter, 1994). Ewel (1990) described melaleuca sites in south Florida as having hydroperiods of six to nine months. Shomer and Drew (1982) noted that melaleuca colonization rates appeared to be inversely proportional to the length of the hydroperiod. Over the past decade, there has been much progress in removing melaleuca along western shore of Lake Okeechobee. Melaleuca control has been focused on areas adjacent to the rim canal, on spoil islands peripheral to the HHD, in wetland pockets behind the dike, and in the western littoral zone. Through the aggressive eradication programs carried out, melaleuca is at manageable levels at this time in Lake Okeechobee.

Brazilian pepper (*Schinus terebinthifolius*), an invasive exotic species, is frequently associated with ditch banks (Barber 1994) and is commonly found along canal banks within Lake Okeechobee. Very little is known about its hydroperiod requirements, but Duever et al. (1986) found that it thrives in areas with three to four month hydroperiods, while Doren and Jones (1994) stated that it rarely grows on sites flooded longer than three to six months, and is absent from deeper wetland communities. As with melaleuca, Brazilian pepper removal efforts are continuous around Lake Okeechobee.

Australian pine (*Casuarina spp.*), an invasive exotic species, is a major invader of short hydroperiod areas where it can be found in dense stands, which preclude establishment of native species. One of the species (*C. quinquenervia*) is intolerant of extended inundation, but another (*C. glauca*) invades sawgrass marsh and burned hardwood hammocks in the Everglades (Doren and Jones 1994). Until recently, Australian pine was commonly found along the rim canal and in monotypic stands on the berm of the HHD and in areas behind the dike. Over the past decade, eradication and removal efforts have been successful in removing this tree on the berm of HHD.

Another exotic that continues to plague resource managers throughout Lake Okeechobee is torpedo grass, which is spreading rapidly into areas of spike rush, where it forms dense rooted mats and appears to be tolerant of a wide variety of hydroperiods. Other species include water hyacinth (native to South America) and water lettuce, which clog waterways and are found primarily in canals and backwater areas as well as in Lake Okeechobee, and both may root in wet soil. These latter two species, along with hydrilla, pose navigation problems for boaters and fisherman, flood control and water supply challenges for water managers, and are among the principal species targeted by aquatic plant control efforts by the Corps.

5.2.2. ST. LUCIE ESTUARY

Seagrasses were once common in the St. Lucie Estuary, but virtually disappeared over the years, except for areas around the St. Lucie inlet near Indian River Lagoon. Seagrass meadows improve water quality by removing nutrients, dissipating the effects of waves and currents, and by stabilizing bottom habitats, thereby reducing suspended solids. Seagrass beds support some of the most abundant fish populations in the Indian River Lagoon, with large species diversity. Seagrass and macroalgae (collectively referred to as SAV) are highly productive areas and are perhaps the most important habitat of the Indian River Lagoon (IRL CCMP, 1996). Pinfish (*Lagodon rhomboides*) and several species of mojarra (Gerreidae) are very abundant in the seagrass habitat. These species are known to feed on seagrasses and on the epiphytes and epifauna of the seagrasses, providing a critical link in the food chain between the primary producers and the higher level consumers such as the common snook (*Centropomus undecimalis*) and spotted seatrout (*Cynoscion nebulosus*).

The natural shoreline and inter-tidal areas of the St. Lucie Estuary were once populated by mangroves and other detritus producing vegetation, but now due to shoreline alterations supports very little vegetation. In many areas, seawalls and docks have replaced mangroves and seagrasses. Freshwater from the St. Lucie River basin and Lake Okeechobee releases influence estuarine water quality and composition, contributing to adverse effects to seagrasses in this system. Most SAV coverage in the St. Lucie Estuary is only found near the Indian River Lagoon. Those species known to occur near the Indian River Lagoon are shoal grass (*Halodule wrightii*), wigeon grass (*Ruppia maritima*), and Johnson's seagrass (*Halophila johnsonii*), star grass (*Halophila engelmannii*) and paddle grass (*Halophila decipiens*).

5.2.3. CALOOSAHATCHEE RIVER/ESTUARY

The Section of the Caloosahatchee River from Lake Okeechobee to S-79 was originally a meandering river with natural vegetation along its riverbanks. Since the late 1800's, the river has been extremely altered by dredging practices, impacting a majority of the aquatic and shoreline vegetation. When the Caloosahatchee was channelized, much of the spoil from the project was placed at locations along the banks. Channelizing the river changed the hydrology of the area and provided a location for exotic plant invasion. Many exotic vegetation species such as Brazilian pepper, water lettuce and water hyacinth have, and continue to, alter native plant communities of the Caloosahatchee River. Today, the remnant oxbows support the some of the only remaining natural riverine vegetation in the altered river system. Some common native species that may exist along the river are floating plants such as Fragrant water lily (*Nymphaea odorata*), emergent plants such as pickerelweed (*Pontederia cordata*), duck potato (*Sagittaria lancifolia*), bulrush (*Scirpus validus*), and submerged plants such as tapegrass (*Vallisneria Americana*). Along the banks of the river native plants such wax myrtle (*Myrica cerifera*) and Virginia willow (*Itea virginica*) may be found.

Seagrasses are undoubtedly among the most important vegetation of the Caloosahatchee Estuary. In the Caloosahatchee River the primary species of importance is *Vallisneria* (*Vallisneria americana*), also known as tape grass and

commonly found in still and fast flowing waters. In the Caloosahatchee River, *Vallisneria* is used extensively as an indicator species as it has proven to be an excellent ecological representative for a wide variety of other biota for this area. Although *Vallisneria* is salt tolerant, it is a freshwater plant species. During times of extended low inflow conditions, when salinity is too high in the upper estuary, this grass becomes very sparse and can disappear completely (Doering et al., 2002). When growing conditions are favorable, the most extensive beds are found in the 640 acre area between Beautiful Island and the Ft. Myers Bridge which constitutes about 60 percent of the reported areal coverage of the species in the Caloosahatchee (SFWMD, 2002). *Vallisneria* is a valuable waterfowl food and is considered an excellent plant for fish spawning areas along the river margin.

Shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*), and manatee grass (*Syringodium filiforme*) are the most common higher salinity grasses in the Caloosahatchee Estuary.

Approximately 2,995 acres of mangroves are found in the Lower Caloosahatchee River Subbasin (Post, Buckley, Schuh, and Jernigan, 1999). In the Caloosahatchee Estuary, mangroves support fish and macro-invertebrate communities by providing protected nursery areas for fishes, crustaceans, and shellfish, and food for a multitude of commercial and recreational marine species. Urbanization and shoreline development has resulted in an extensive loss of mangrove habitat along the Caloosahatchee Estuary.

5.2.4. LAKE WORTH LAGOON

Seagrasses cover approximately 35 percent of the total submerged area of Lake Worth Lagoon (PBCDERM, 1998). Three species of seagrass found within the lagoon are Johnson's seagrass (*Halophila johnsonii*), shoal grass (*Halodule wrightii*) and paddle grass (*Halophila decipiens*). As an estuary, Lake Worth Lagoon has developed to serve as spawning, nursery, and feeding grounds for many fish and invertebrate species. Some mangrove communities still exist along the shoreline of the lagoon.

5.2.5. EVERGLADES AGRICULTURAL AREA

The EAA is located on the southern tip of Lake Okeechobee and is one of the most productive agriculture regions in the State. Over 505,000 acres of the EAA are under production with sugar cane that accounts for over 80 percent of total crop coverage (USEPA, 2006). Lake Okeechobee provides water south to the EAA (Figure 5-3) through three structures, S-351, S-354, and S-352. The EAA, covering 1,122 square miles south of Lake Okeechobee is the largest contiguous area of historic Everglades cover that has been converted by land use practices. The EAA historically consisted of several different plant communities. A dense swamp of pond apple, willow and elderberry formed broad bands along the southern rim of Lake Okeechobee. The remainder of what is now the EAA was dominated by sawgrass marshes. The present EAA contains primarily agricultural cropland.

Several large tracts of land at the south end of the EAA were never directly converted to agricultural lands, although seasonal water patterns have been greatly altered by water management practices. These areas are known as the Holey Land and Rotenberger WMAs, and the former Brown's Farm WMA (now converted to STA 2). These three areas comprise approximately 18 percent of the EAA and retain much of their historic sawgrass marsh and associated plant communities, although the plant cover has been altered by hydroperiod changes, fires, soil subsidence and invasion of exotic plant species and cattail. It is not expected that these areas will experience any modification to their existing in-flows under the LORS alternatives and are thus not further discussed.

5.2.6. WATER CONSERVATION AREAS (GREATER EVERGLADES)

The WCAs comprise about one-third of the original Everglades. The area is currently divided into five shallow water impoundments surrounded by levees and canals. These impounded marshes are managed to provide flood protection to the cities and farms to the east and to provide water for agricultural and municipal use during the dry season.

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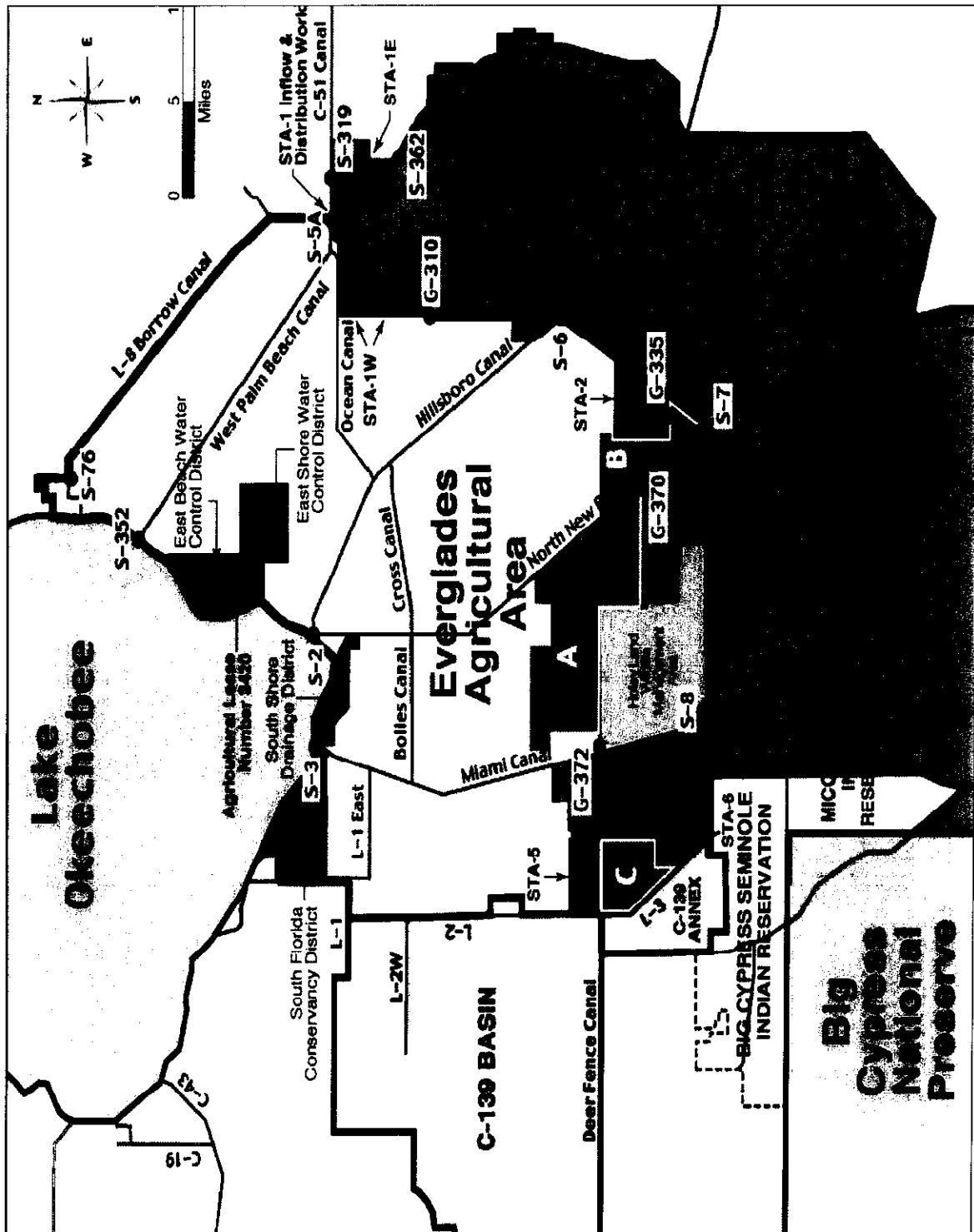


FIGURE 5-3: LOCATION OF EAA AND WCAS

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The WCAs are vegetated with a mosaic of habitat types dominated by sawgrass. Nearly all of the WCAs (Figure 5-3) are a patterned peatland, consisting of long, linear sawgrass ridges interspersed with teardrop-shaped tree islands (hammocks) and willow strands. Tree islands are a unique feature of the Everglades ecosystem. Tropical hardwoods are found on some of the relatively unaltered tree islands in the southern portion of the area. The landscape pattern of ridge and slough has been altered significantly but appears largely intact in portions of the WCAs and into ENP (Science Coordinating Team 2003).

The ridge and slough patterns were developed in broad, shallow to intermediate depth basins with peat substrate in response to the original hydrologic flow regimes of the Everglades. The dominant plant cover is sawgrass and/or buttonbush and/or mixed emergents. In general, there are now three recognizable types of basin wetland communities present:

1. Sawgrass ridges now interspersed, composed of sawgrass, with cattail, maidencane, arrowhead, pickerelweed, willow, button bush, wax myrtle (*Myrica cerifera*), and saltbush (*Baccharis glomeruliflora*).
2. Wet prairie, composed of beak rush, spike rush, maidencane, string lily (*Crinum americanum*), and white water lily.
3. Aquatic slough, composed of white water lily, floating heart (*Nymphoides aquatica*), spatterdock (*Nuphar luteum*), bacopa (*Bacopa caroliniana*), and bladderwort.

The following species are associated with some portions of this community: pond cypress (*Taxodium ascendens*), bald cypress (*Taxodium distichum*), willow, buttonbush, wax myrtle, sawgrass, and royal fern (*Osmunda regalis*).

A hydric hammock is a wetland forest community that occurs in lowlands over sandy, clay organic soil, often over limestone. Its water regime is mesic to hydric; climate is subtropical or temperate; and fire is rare or not a major factor. The following species are associated with this community: sweet bay (*Magnolia virginiana*), red bay (*Persea borbonia*), cocoplum (*Chrysobalanus icaco*), strangler fig (*Ficus aurea*), wax myrtle, willow, elderberry (*Sambucus simpsonii*), hackberry, cabbage palm (*Sabal palmetto*), red maple (*Acer rubrum*), false nettle (*Boehmeria cylindrica*), water oak (*Quercus nigra*), hornbeam, and needle palm (*Rhapidophyllum hystrix*).

Vegetation within the WCA 1 consists of a matrix of wet prairies, sawgrass prairies, and aquatic slough communities with some ridge and slough patterning. Tree islands are interspersed throughout the area. Plant community cover within WCA 1 has shifted as a result of impoundment of the marsh by perimeter levees and alteration of hydroperiods by the C&SF Project operation. The southern, lower elevation areas of WCA 1 have been flooded for long periods of time, while the northern portions of the area have experienced more frequent drying. Areas which have experienced shortened hydroperiods have experienced shifts to woody vegetation (wax myrtle and willow), while lower elevations have experienced shifts to more aquatic flora. In addition,

WCA 1 currently includes approximately 6,000 acres (four percent total cover) of cattail marsh that was not present prior to the early 1960s. A number of factors influence establishment of cattails in the Everglades. These include physical disturbance of underlying soil profile by canal construction activities, proximity to seed sources, fire, hydrologic changes and the availability of nutrients. Exotic vegetation that was uncommon prior to 1965 is a growing problem. Melaleuca and Brazilian pepper are both rapidly spreading along the perimeter and into the interior marsh. Old World climbing fern (*Lygodium microphyllum*) is also a major invasive exotic species in WCA 1.

Major plant communities in WCA 2A now consist of remnant drowned tree islands, open water sloughs and large expanses of sawgrass, and sawgrass intermixed with dense cattail (*T. domingensis*) stands. Some remnant ridge and slough patterning remains. Remaining tree islands are found primarily at higher ground level elevations, located in the northwest corner of WCA 2A. Remnant (drowned) tree islands, dominated primarily by willow, are found scattered throughout the central and southern sections of WCA 2A.

Several studies conducted within WCA 2A show that cattails out-compete sawgrass in their ability to absorb nutrients. There is increased cattail production during years of high nutrient inflows (Toth, 1988; Davis, 1991). Cattails are considered a high nutrient status species that is opportunistic and highly competitive, relative to sawgrass, in nutrient-enriched situations (Toth, 1988; Davis, 1991). Davis (1991) concluded that both sawgrass and cattail increased annual production in response to elevated nutrient concentrations, but that cattail differed in its ability to increase plant production during years of high nutrient supply.

The community structure and species diversity of Everglades vegetation located north of I-75 (WCA 3A North) is very different from the wetland plant communities found south of I-75 (WCA 3A South). Improvements made to the Miami Canal and impoundment of WCA 3A by levees during the early to mid-1900s have over-drained the north end of WCA 3A and shortened its natural hydroperiod. These hydrological changes have increased the frequency of severe peat fires that have resulted in loss of tree islands, sawgrass ridges, aquatic slough, and wet prairie habitat that were once characteristic of the area. Today, northern WCA 3A is largely dominated by sawgrass and lacks the natural structural diversity of plant communities seen in southern WCA 3A. Most of the ridge and slough patterning is severely degraded.

Over drainage of the northwestern portion of WCA 3A has allowed the invasion of a number of terrestrial species such as salt bush (*B. halimifolia*), dog fennel, and broom sedge (*Andropogon* spp.). Melaleuca has become well established in the southeastern corner of WCA 3A North, and is spreading to the north and west.

Everglades vegetation located in the central and southern portion of WCA 3A probably represents some of the best examples of original, undisturbed Everglades habitat left in south Florida. This region of the Everglades appears to have changed little since the

1940s, and contains a mosaic of tree islands, wet prairies, sawgrass stands, and aquatic sloughs similar to those reported by Loveless (1959). The existing ridge and slough patterning is largely intact spatially, although the vertical difference between ridge tops and slough bottoms has lessened.

The majority of vegetation within WCA 3A south can be described as typical Everglades habitat with some exceptions due largely to the canalization and construction of levees which compartmentalize the WCAs. Water depths in southern WCA 3A are deeper than they would be without levees and Tamiami Trail.

5.3. THREATENED AND ENDANGERED SPECIES

Federally endangered and threatened species known to occur within the project area include:

COMMON NAME	SCIENTIFIC NAME	STATUS
Everglade snail kite	<i>Rostrhamus sociabilis plumbeus</i>	E(CH)
Wood stork	<i>Mycteria americana</i>	E
West Indian manatee	<i>Trichechus manatus</i>	E(CH)
Bald eagle	<i>Haliaeetus leucocephalus</i>	T
Eastern indigo snake	<i>Drymarchon corais couperi</i>	T
Cape sable seaside sparrow	<i>Ammodramus maritimus mirabilis</i>	E
Okeechobee gourd	<i>Cucurbita okeechobeensis</i>	E
Small-toothed sawfish	<i>Pristis pectinata</i>	E
Johnson's seagrass	<i>Halophila johnsonii</i>	T

E=Endangered; T=Threatened; CH=Critical Habitat has been designated

5.3.1. EVERGLADE SNAIL KITE

The snail kite occupies the watersheds of the Everglades, Kissimmee River, Caloosahatchee River, the upper St. Johns River, and Lake Okeechobee. "Each of these watersheds has experienced, and continues to experience, pervasive degradation due to urban development and agricultural activities" (USFWS, 1999). Snail kite habitat consists of freshwater marshes and the shallow vegetated edges of lakes where the apple snail (*Pomacea paludosa*), the kite's main food source, can be found. Snail kite populations in Florida are highly nomadic and mobile; tracking favorable hydrologic conditions and food supplies, and thus avoiding local droughts. Snail kites move widely throughout the primary wetlands of the central and southern portions of the State of Florida. Lake Okeechobee and surrounding wetlands are major nesting and foraging habitat, particularly the large marsh in the southwestern portion of Lake Okeechobee and the area southwest of the inflow of the Kissimmee River (USFWS, 1999). Critical habitat was designated for the snail kite in 1977. Critical habitat includes the entire littoral zone and western shore of Lake Okeechobee.

The snail kite has a highly specialized diet typically composed of Florida apple snails, which are found in palustrine, emergent, long-hydroperiod wetlands. As a result, the snail kite's survival is directly dependent on the hydrology and water quality of its habitat

(USFWS, 1999). Snail kites require foraging areas that are relatively clear and open in order to visually search for apple snails. Suitable foraging habitat for the snail kite is typically a combination of low profile marsh and a mix of shallow open water. Shallow wetlands with emergent vegetation such as spike rush, bulrush, and other native emergent wetland plant species provide good snail kite foraging habitat as long as the vegetation is not too dense to locate apple snails. Dense growth of plants reduces the ability of the snail kite to locate apple snails. The degradation of water quality in Lake Okeechobee, due in part to runoff of phosphorus from agriculture lands, promotes dense growth of both native and exotic vegetation, in particular cattail, water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*), which inhibits the ability of snail kites to find food. Bennetts and Kitchens (1997) noted that quality of habitat for kites is adversely influenced by changes in water quality and expansion of non-native plants. Lake Okeechobee has experienced high rates of phosphorus loading in recent decades due to altered land use in the watershed. At present, phosphorus loading is in excess of 500 metric tons per year (Havens & Gawlick, 2005), compared to the Florida Department of Environmental Protection's (FDEP) recommended annual load of 140 metric tons (FDEP, 2001).

Snail kite nesting primarily occurs from December to July (peak in March-June), but can occur year-round. Nesting usually occurs over water, which deters predation. Nesting substrates include small trees such as willow and pond apple, and in herbaceous vegetation such as sawgrass, cattail, bulrush and reed. Kites appear to prefer woody vegetation when water levels are adequate to inundate the site (Rodgers, 1996). Nests are more frequently placed in herbaceous vegetation around Lake Okeechobee during periods of low water when dry conditions beneath willow stands (which tend to grow to the landward side of cattails, bulrushes and reeds) prevent snail kites from nesting in woody vegetation (USFWS, 1999). Nest collapse is rare in woody vegetation but common in non-woody vegetation, especially on lake margins (Rodgers, 1996).

Historically, Lake Okeechobee's littoral zone has provided one of South Florida's largest habitats for the snail kite (Bennetts and Kitchens, 1997). However, species experts have reported a decline in the overall Florida population estimate for the snail kite in recent years, as well as a lack of substantial numbers of snail kite nests in Lake Okeechobee. Observations since 1992 suggest a general degradation of nesting habitat in the littoral zone of Lake Okeechobee from the loss of willows in nesting areas (USFWS, 1999).

The south/central Florida region, including Lake Okeechobee, has experienced extreme weather events over the past few years. For instance, a regional drought occurred in 2000-2001, and above average rainfall in 2004 and 2005. Above average rainfall coupled with very active hurricane seasons in 2004 and 2005, has allowed less favorable conditions in the littoral zone of Lake Okeechobee. The major hurricanes of 2004 (Frances and Jeanne) caused significant ecological damage inside Lake Okeechobee, uprooting much of the lake's submerged vegetation and causing suspension and transport of soft mud sediments from the center of the lake to the shallow shoreline areas (Havens, 2005b). As a result, Lake Okeechobee remained

highly turbid for months after the hurricanes. The combination of high turbidity and deep water blocked light penetration to the lake bottom in shoreline areas (Havens, 2005). Lack of suitable light penetration can adversely impact SAV in Lake Okeechobee.

During years 2000-2001, snail kite survival dropped substantially in response to the regional drought (Kitchens et al., 2006). Lake Okeechobee had a record low stage of 9.2 ft., NGVD, at which time much of the shoal area became dry (Havens, et. al., 2005). Droughts, such as the one that occurred in 2000-2001, can severely impact the snail kite's forage and nesting habitats. In particular, snail availability to kites is greatly reduced during droughts (Beissinger, 1995). When droughts lead to a drying out (dry-down) of a breeding site during breeding season, droughts have a negative effect on survival and reproduction of snail kites (Bennets and Kitchens, 2000). To date, the assumption has been that during a drought, snail kites move from areas most affected by drought toward areas least affected by drought (Martin, et al., 2006). In extreme droughts, Lake Okeechobee is sometimes the only major wetland habitat with adequate water levels which are suitable for foraging and nesting (Havens & Gawlick, 2005). Havens and Gawlick (2005) report that the prolonged period of extreme low stage in 2000-2001 appeared to have nearly eliminated the apple snail population from Lake Okeechobee's littoral zone. However, it is also important to note that dry-downs are not necessarily harmful to apple snail populations, as long as they do not coincide with the peak period of egg-production or last for many months (Havens & Gawlick, 2005).

Even though drought conditions have negative effects, it is also recognized that occasional droughts are necessary to maintain native emergent vegetation such as spike rush, which is favorable to snail kite foraging.

Regulation of water stages in Lake Okeechobee is particularly important to maintain the balance of vegetative communities required for snail kites and the apple snail. Fluctuation and timing of lake stages affect the distribution of vegetative communities, and overall habitat quality (nesting sites, foraging habitat) for the snail kite. According to the USFWS (1999), a water stage of 14.5-15.0 ft. NGVD on Lake Okeechobee is recommended near the beginning of the snail kite nesting season during most years, with a gradual recession in late winter to late spring. This water stage coincides with several ecological studies on the littoral system of Lake Okeechobee. These studies have shown that a spring recession of lake levels from near 15 ft. to 12 ft. NGVD (January through May) favors nesting birds and other wildlife in the littoral marsh and allows for re-invigoration of willow stands (Smith et al., 1995). It is the extreme prolonged high and low lake levels which are undesirable for the Lake Okeechobee ecosystem. Factors contributing to habitat loss in Lake Okeechobee include prolonged periods of deep water and expansion of exotic vegetation (during low lake levels) such as torpedograss (Havens and Gawlick, 2005).

5.3.2. BALD EAGLE

UPDATE: When the draft revised SEIS was prepared in early June 2007, the bald eagle was listed as threatened by the USFWS and the Florida Fish and Wildlife

Conservation Commission (FFWCC). Since release of the draft, on June 28, 2007, the Secretary of the Interior announced the removal of the bald eagle from the list of threatened and endangered species. Even though they are delisted, bald eagles are still protected by the Migratory Bird Treaty Act and the Bald Eagle Protection Act.

The bald eagle occurs in various habitats near lakes, large rivers and coastlines. Most breeding eagles construct nests within several hundred yards of open water (USFWS, 1999). Shorelines, such as the shorelines around Lake Okeechobee, the Okeechobee Waterway, and estuaries provide fishing and loafing perches, nest trees, and open flight paths for the bald eagle (USFWS, 1999). The bald eagle primarily feeds on fish, but is known to occasionally prey on small mammals and will feed on carrion. Bald eagles are known to nest around the study area. Nesting season occurs from October through May. The bald eagle mates for life and uses the same nesting site year after year, if the territory is available. According to the FFWCC database, for the period of 2000-2004, two nests were reported in close proximity to Lake Okeechobee. One nest, located in Palm Beach County near Lake Harbor, was last listed as active in 2003. The second nest, located in Glades County northeast of Lake Port, was active in 2004.

5.3.3. WOOD STORK

The wood stork is listed as endangered by the USFWS and the FFWCC. Wood storks forage in freshwater marshes, seasonally flooded roadside or agriculture ditches, narrow tidal creeks, shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Wood storks typically feed on fish between two and 25 centimeters (cm) in length. Wood storks have nested in small numbers around Lake Okeechobee, and are regularly seen foraging in the area (Smith, et al., 1995). Data gathered by Smith, et al., (1995) indicate that wood storks are attracted to Lake Okeechobee in large numbers only when the stage drops below 15 ft., NGVD. A lake stage above 15 ft., NGVD eliminates most of the foraging habitat available to wading birds on Lake Okeechobee (Aumen and Gray, 1995), whereas a lake stage below 11.8 ft., NGVD reduces the diversity of available foraging habitats and the number of acceptable nesting colony sites (Smith et al., 1995). As Aumen and Gray (1995) discuss, a regulation schedule for Lake Okeechobee benefiting wading birds should include a moderately paced draw down in water level to below 15 ft., NGVD coincident with the dry season and the usual wading bird nesting season (January–June).

5.3.4. CAPE SABLE SEASIDE SPARROW

Cape Sable Seaside Sparrow (CSSS) are medium-sized sparrows restricted to the Florida peninsula. They are non-migratory residents of freshwater to brackish marshes (USFWS, 1999). CSSS have a very restricted range and occur only in the Everglades region of Miami-Dade and Monroe counties of south Florida (USFWS, 1999). Critical habitat for the sparrow was designated on August 11, 1977 under Title 50 of the Code of Federal Regulations Part 17.95 (50 CFR 17.95). A key constituent element for the CSSS should be a hydroperiod pattern that maintains the preferred vegetative communities for successful breeding. During the breeding season, surface water levels should be at or below the surface within the short-hydroperiod prairies, and should be

achieved through adherence to a rainfall-driven operational schedule within its habitat (USFWS, 1999).

5.3.5. WEST INDIAN MANATEE

The West Indian manatee has been classified as an endangered species since 1967. The manatee lives in freshwater, brackish, and marine habitats and prefers water depths of at least three to seven feet. Water temperature colder than 77 degrees Fahrenheit increases the manatee's susceptibility to cold stress and cold induced mortality. Primary threats to manatees today are attributed to collisions with watercraft, degradation of habitat, and accidents occurring at water control structures. Manatees feed on a variety of submerged, emergent and floating vegetations and usually forage in shallow grass beds adjacent to deeper channels. During the summer months, manatees range throughout water bodies of south Florida. In the winter months, manatees tend to congregate in warm water areas such as springs and power plant facilities e.g., the Florida Power and Light power plant at Ft. Myers, adjacent to the Caloosahatchee National Wildlife Refuge. A park has been established in this vicinity for manatee viewing. The utilization of Lake Okeechobee and the tributaries and canal systems in south Florida by the manatee is not uncommon. Manatees are often seen in the Caloosahatchee River, St. Lucie Canal and Lake Okeechobee. The Caloosahatchee River Estuary also serves as critical habitat for the manatee. The Caloosahatchee National Wildlife Refuge located adjacent to I-75 on the Caloosahatchee River serves as a refuge for the manatee. The manatee is known to move through the Okeechobee Waterway lock structures when traveling to and from the coast.

5.3.6. OKEECHOBEE GOURD

The Okeechobee gourd is an annual or perennial, fibrous-rooted, high-climbing vine with tendrils, belonging to the gourd family *Cucurbitaceae* (USFWS, 1999). Today, the Okeechobee gourd has an extremely limited distribution. Lake Okeechobee is one of two areas where the gourd is currently found. There are several localized sites along the southeastern and northeastern shore of Lake Okeechobee, where this vine plant is known to grow. Around Lake Okeechobee, the gourd relies on pond apple trees to support its vines above rising water levels during the wet season. Water management levels in Lake Okeechobee affecting the snail kite and wood stork are also likely to affect the Okeechobee gourd. Fluctuating lake levels are necessary for the continued survival and recovery of the gourd within and around Lake Okeechobee. The endangered Okeechobee gourd flourishes when suitable soils are exposed during low water levels (USFWS, 1999).

5.3.7. EASTERN INDIGO SNAKE

The Eastern indigo snake has been classified as a threatened species by the USFWS and the FFWCC. The Eastern indigo snake is a large, black, non-venomous snake in North America. The Eastern indigo prefers drier habitats, but may be found in a variety of habitats from xeric sand hills, to cabbage palm hammocks, to hydric hardwood hammocks (Schaefer and Junkin, 1990). This species is generally an upland species snake, occupying a wide variety of habitat. The main reason for the snakes decline is

habitat loss due to development. Further, as habitats become fragmented by roads, Eastern indigo snakes become increasingly vulnerable to highway mortality as they travel through their large territories (Schaefer and Junkin, 1990). The HHD and other levees within the Lake Okeechobee project area would be the primary area the snake would utilize.

5.3.8. SMALLTOOTH SAWFISH

The endangered smalltooth sawfish (*Pristis pectinata*) is one of two species of sawfish that inhabit United States (U.S.) waters. The U.S. population of smalltooth sawfish experienced severe range reduction and decline over the last century. The biology and ecology of *P. pectinata* is poorly known and the species was thought to be close to extirpation from United States waters before moderate numbers of individuals were recently documented in Florida, particularly south and southwest Florida. In the western Atlantic, the smalltooth sawfish has been reported from Brazil through the Caribbean and Central America, the Gulf of Mexico, and the Atlantic coast of the U.S. The smalltooth sawfish was listed as a Federally endangered species in 2003.

Smalltooth sawfish commonly reach five and one half meters. Little is known about the life history of these animals, but they may live up to 25-30 years and mature after about ten years. Like many elasmobranchs (e.g. sharks), smalltooth sawfish are ovoviparous, meaning the mother holds the eggs inside her until the young are ready to be born. Sawfish species inhabit shallow coastal waters of tropical seas and estuaries throughout the world. Sawfish are most often found within a mile of land such as in estuaries, river mouths, bays, or inlets. They occur in a wide range of habitat types including seagrass flats, mud bottoms, oyster bars, sand bottoms, artificial reefs, coral reefs, and mangrove shorelines. It has been reported that the smalltooth sawfish can tolerate a wide range of salinities, including freshwater (Compagno and Cook, 1995 reference by Simpfendorfer and Wiley, 2005). During a recent study, Simpfendorfer and Wiley (2005) reported no encounters of the smalltooth sawfish in areas of permanent freshwater. However, many encounters were reported at the mouths of rivers or other sources of freshwater inflow, suggesting that estuarine areas may be an important factor in their distribution. The smalltooth sawfish has been reported to be found in the Caloosahatchee River, particularly in the lower parts of the river near the mouth (personal correspondence, G. Poulakis, FFWCC). This portion of the river is where the majority of sawfish are caught and tagged by FFWCC for research and monitoring purposes. Additionally, anglers most commonly report seeing and catching the species in the lower parts of the river near the mouth.

Smalltooth sawfish generally eat whatever small schooling fish may be abundant locally, such as mullet. They may also feed on crustaceans and other benthic organisms. The sawfish has been seen as "stirring the mud with its saw" to locate its prey, or attacking schools of small fish by slashing sideways with its saw and eating the wounded fish (NMFS, 2000).

5.3.9. JOHNSON'S SEAGRASS

The threatened Johnson's seagrass (*Halophila johnsonii*) has been found growing only along approximately 200 kilometers (km) (approximately 125 miles) of the coastline in southeastern Florida from Sebastian Inlet, Indian River County to northern Key Biscayne. This narrow range and apparent endemism indicates that Johnson's seagrass has the most limited geographic distribution of any seagrass in the world.

Johnson's seagrass occurs in dynamic and disjunct patches throughout its range. Growth appears to be rapid and leaf pairs have short life spans while horizontally spreading from dense apical meristems (Kenworthy, 1997). Kenworthy suggested that horizontally spreading rapid growth patterns and a high biomass turnover could explain the dynamic patches observed in distribution studies. New information reviewed in Kenworthy (1999, 1997) confirms *H. johnsonii*'s limited geographic distribution in patchy and vertically disjunct areas between Sebastian Inlet and northern Biscayne Bay.

Johnson's seagrass occurs over varied depths, environmental conditions, sand substrates, and water quality. In tidal channels, *H. johnsonii* is found in coarse sand substrates, although it has been found growing on sandy shoals in soft mud near canals and rivers where salinity may fluctuate widely (Virnstein et al., 1997).

Areas of concern for this species include seagrass beds located in proximity to rivers and canal mouths where low salinity, highly colored water is discharged. Freshwater discharge into areas adjacent to seagrass beds may provoke physiological stress upon the plants by reducing the salinity levels. Additionally, colored waters released into seagrass areas reduce the amount of sunlight available for photosynthesis.

Personal communication with local scientists, seagrass monitoring data from the SFWMD and St. Johns River Water Management District, and a resource inventory by Palm Beach County Department of Environmental Resources Management show *H. johnsonii* is present in Lake Worth Lagoon and near the mouth of the St. Lucie inlet.

5.3.10. STATE LISTED SPECIES

Additional State listed species present within the effected area, and which may be affected by regulation schedule alternatives are presented in Table 5-1.

TABLE 5-1: STATE LISTED SPECIES

Scientific Name	Common Name	USFWS	FFWCC
<i>Trichechus manatus</i>	West Indian manatee	E	E
<i>Rostrhamus sociabilis plumbeus</i>	snail kite	E	E
<i>Mycteria americana</i>	wood stork	E	E
<i>Haliaeetus leucocephalus</i>	bald eagle	T	T
<i>Ammodramus maritimus mirabilis</i>	Cape sable seaside sparrow	E	E
<i>Drymarchon corais couperi</i>	Eastern indigo snake	T	T
<i>Alligator mississippiensis</i>	American alligator		SSC
<i>Ajaja ajaja</i>	roseate spoonbill		SSC
<i>Aramus guarauna</i>	limpkin		SSC
<i>Egretta caerulea</i>	little blue heron		SSC
<i>Egretta rufescens</i>	reddish egret		SSC
<i>Egretta thula</i>	snowy egret		SSC
<i>Egretta tricolor</i>	tri-colored heron		SSC
<i>Eudocimus albus</i>	white ibis		SSC
<i>Grus canadensis pratensis</i>	Florida sandhill crane		T
<i>Pelecanus occidentalis</i>	brown pelican		SSC
<i>Rhynchos niger</i>	black skimmer		SSC
<i>Centropomus undecimalis</i>	common snook		SSC
<i>Cucurbita okeechobeensis</i>	Okeechobee gourd	E	E
<i>Pituophis melanoleucus mugitus</i>	Florida pine snake		SSC

5.4. FISH AND WILDLIFE RESOURCES

As with the above discussion of existing vegetation, the below discussion of fish and wildlife resources inhabiting the study area is organized by physiographic area, beginning with Lake Okeechobee itself, the estuaries, EAA and concluding with the WCAs.

5.4.1. LAKE OKEECHOBEE

The area around Lake Okeechobee includes a wide variety of habitat opportunities for wildlife, including wading and migratory birds, many mammals, amphibians, and reptiles, as well as prey species such as crayfish, prawns, apple snails (*Pomacea paludosa*), and aquatic insects. The USFWS has designated six wildlife species as threatened or endangered and likely to occur in the vicinity of the Lake Okeechobee study area (Section 5.3). There are also State-listed species present within and around Lake Okeechobee, including several of the wading bird species that are not on the Federal list. The Corps conducted a two year wildlife survey within the western littoral zone of Lake Okeechobee, gathering baseline data for key habitat types for reptiles, amphibians, and migratory and resident birds (USACE, 1999). Much of the information below was gathered from the study.

Lake Okeechobee is home to a large number of fish species, some of which are valued as commercial and sportfish, and others serving as part of the cornerstone of the littoral zone food web. The USACE (1999) found numerous small fish species, including the Cyprinodontids such as the golden topminnow (*Fundulus chrysotus*), the least killifish (*Heterandria formosa*), and the Florida flagfish (*Jordanella floridae*) which are important food resources for wading birds, amphibians, and reptiles. Over a five-year period (1987-1991), mean annual commercial harvest was 2,008 metric tons (Fox, et al., 1992, 1993). Commercially important fish species included white catfish, bluegill, and red-ear sunfish.

Additionally, Furse and Fox (1994) revealed that numerous sportfish occur in the littoral zone. The largemouth bass (*Micropterus salmoides*) is one of the most popular gamefish in the State of Florida, and is a major predator of small fish, amphibians, birds, and reptiles. Additionally, the black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and redear sunfish (*L. microlophus*) are sportfish found in high numbers in the littoral zone.

Macroinvertebrate diversity in the western littoral zone provides yet another vital component to the food web. Macroinvertebrate species incidentally sampled during field investigations in the western littoral zone included the apple snail, an important food resource of the snail kite (*Rostrhamus sociabilis plumbeus*), crayfish (*Procambarus* spp.), grass shrimp (*Paleomonetes paludosus*), and Dytiscid beetles (Dytiscidae).

Significant changes in recent years have been observed on Lake Okeechobee. Valuable fish habitat including bulrush, spike rush and SAV has been lost and/or replaced by exotic species such as torpedograss and hydrilla. Reports of muddy, turbid water, and drowned vegetation are not uncommon among the public and fisherman. Fishing guides report fish spawning has been poor for the last five years. Others report that shiners (an important bait fish) are becoming increasingly difficult to find and more and more fishermen are forced to the same areas to fish for them.

A major area of concern to the life cycle of fish and wildlife species is the western littoral zone and marsh, thus the description below will focus on this area as a representative of similar littoral resources around Lake Okeechobee.

The western littoral zone provides tremendous foraging and nesting habit for a wide range of avifauna. Previous studies (Smith and Collopy, 1995; David, 1994) have documented birds including the endangered wood stork (*Mycteria americana*), the Federally and State endangered snail kite, great blue heron (*Ardea herodias*), white ibis (*Eudocimus albus*), pied-billed grebe (*Podilymbus podiceps*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), little blue heron (*E. caerulea*), tricolored heron (*E. tricolor*), and common moorhen (*Gallinula chloropus*) that have commonly been observed utilizing the study area.

Other birds that may utilize the littoral zone include the threatened bald eagle (*Haliaeetus leucocephalus*), black skimmer (*Rhyncops niger*), brown pelican (*Pelecanus occidentalis*), double-crested cormorant (*Phalacrocorax auritus*), and anhinga (*Anhinga anhinga*).

According to range maps presented in Conant and Collins (1991), reptile and amphibian diversity should be quite high in littoral and marsh areas of Lake Okeechobee. Studied species on Lake Okeechobee include the American alligator (*Alligator mississippiensis*) and the Florida soft-shelled turtle (*Apalone ferox*) (USACE, 1999). Currently, no published inventories are available on the diversity of reptiles and amphibians inhabiting the western littoral zone of Lake Okeechobee.

The Corps found large numbers of the greater siren (*Siren lacertina*) along with the green water snake (*Nerodia floridana*) and the banded water snake (*N. fasciata*). Additional common species sampled included frogs such as the southern leopard frog (*Rana utricularia*), the green tree frog (*Hyla cinerea*), and the squirrel tree frog (*H. squirlala*). The American alligator was the only listed species of reptile recorded by the Corps and there are no listed species of amphibians currently known to utilize the study area.

Of additional interest is the possibility of colonization of exotic amphibians and reptiles within Lake Okeechobee. Several reports from local residents have confirmed sightings of non-native species of lizards, such as the green iguana (*Iguana iguana*), the spiny-tailed iguana (*Ctenosaura pectinata*), and the brown basilisk (*Basiliscus vittatus*). Established populations of such species could be extremely harmful to native reptile and amphibian populations.

Lake Okeechobee also provides major resources for mammals. The Okeechobee Waterway, a designated channel that runs around the perimeter of the lake, as well as across the lake, provides habitat for the endangered West Indian manatee (*Trichechus manatus latirostris*). Additionally, river otters (*Lutra canadensis*), bobcats (*Felis rufus*), and the Florida water rat (*Neofiber alleni*), a species of special concern as listed by the

Florida Committee for Rare and Endangered Plants and Animals, have been observed within the Lake Okeechobee area.

5.4.2. NORTHERN ESTUARIES

The northern estuaries refer to the St. Lucie Estuary on the east coast of Florida (which flows into the Indian River Lagoon), the Caloosahatchee Estuary on the west coast of Florida, and the Lake Worth Lagoon on the east coast in Palm Beach County.

St. Lucie Estuary

The Indian River Lagoon system is a biogeographic transition zone, fed by the St. Lucie Estuary, rich in habitats and species, with the highest species diversity of any estuary in North America (Gilmore, 1977). Species diversity is generally high near inlets and toward the south, and low near cities where nutrient input, freshwater input, sedimentation, and turbidity are high and where large areas of mangroves and seagrasses have been lost. For biological communities and fisheries, seagrass and mangrove habitats are extremely important (Virnstein and Campbell, 1987).

Most of the predominantly freshwater fishes recorded from the Indian River Lagoon system, such as minnows (Cyprinidae), bullhead catfishes (Ictaluridae), and sunfishes (Centrarchidae) are found mainly or exclusively in the tributary streams including the streams feeding the St. Lucie Estuary. Examples of other species in this habitat include all of the ubiquitous forms mentioned above as well as Florida gar; gizzard shad; flagfish; bluefin killifish (*Lucania goodei*); mosquitofish (*Gambusia affinis*); least killifish; sailfin molly (*Poecilia latipinna*); inland silverside (*Menidia beryllina*); gulf pipefish (*Syngnathus scovelli*); leatherjack (*Oligoplites saurus*); gray snapper (*Lutjanus griseus*); Irish pompano (*Diapterus auratus*); silver jenny (*Eucinostomus gula*); fat sleeper (*Dormitator maculatus*); bigmouth sleeper (*Gobiomorus dormitor*); and lined sole (*Achirus lineatus*). Fish species that specialize in creek-mouth habitats include yellowfin menhaden (*Brevoortia smithi*); gafftopsail catfish (*Bagre marinus*); timucu, a needlefish (*Strongylura timucu*); gulf killifish (*Fundulus grandis*); striped killifish (*F. majalis*); mosquitofish; sailfin molly; lined seahorse (*Hippocampus erectus*); chain pipefish (*S. louisianae*); gulf pipefish; tarpon snook (*Centropomus pectinatus*); Atlantic bumper (*Chloroscombrus chrysurus*); gray snapper; Irish pompano; silver jenny; great barracuda (*Sphyraena barracuda*); gobies, sleepers, puffers, filefish (*Monacanthus spp.*) and many others.

In addition to finfish, the St. Lucie Estuary and Indian River Lagoon support a variety of shellfish. Blue crabs, stone crabs, hard clams and oysters are important estuarine commercial species. The blue crab accounted for approximately 80 percent of shellfish landings in the Indian River Lagoon between 1958 and 1988 (IRL CCMP, 1996).

The American Oyster (*Crassostrea virginica*) is an important indicator organism in the St. Lucie Estuary, because it is known to be sensitive to salinity changes in its environment. Oysters are commonly used as an indicator of spawning season, but many other species of saltwater fish also begin spawning in late winter/early spring.

Without optimum salinity, because of excessive freshwater, other fish species may be affected by fresh water releases.

Caloosahatchee River/Estuary

The Caloosahatchee River from Lake Okeechobee to S-79 hosts a variety wildlife species including birds, amphibians, reptiles, fish, invertebrates and mammals. Species commonly observed along the river are the alligator, manatee, shoreline birds such as herons, egrets and ibis, and birds of prey such as the osprey. These species use the river habitats for nesting and foraging. The Caloosahatchee Estuary starts at the W.P. Franklin Lock and Dam (S-79) and continues downstream nearly 30 miles to San Carlos Bay. Although various changes have historically occurred in the Caloosahatchee Estuary (channelization, shoreline hardening, point and non-point source pollution impacts), the estuary sustains numerous and diverse fish and wildlife populations. Important resources within the estuarine portions of the Caloosahatchee are SAV (i.e. seagrasses), oyster bars, open bottom community, and mangrove-lined shorelines. These communities provide important habitat supporting many wildlife species.

Tape grass (*Vallisneria Americana*) is dominant SAV in the upper Caloosahatchee Estuary and occurs in well-defined beds in shallow water. Extensive beds of tape grass are known to exist between Beautiful Island and the Route 41 bridges in Ft. Myers, when growing conditions are favorable. Tape grass is an important habitat for a variety of freshwater and estuarine invertebrate and vertebrate species, including some commercially and recreationally important fishes (Bortone and Turpin, 1999; Rozas and Minello, 2006). Additionally, tape grass can serve as a food source for the Florida manatee.

Manatees, waterfowl, and wading birds rely on seagrass communities as foraging areas. SAV are an integral nursery area for commercially and recreationally important fish and shellfish. Seagrass communities provide critical refugia for juvenile fish such as redfish, grouper, snook, and spotted seatrout. In addition, the upper and middle portions of the Caloosahatchee River support a blue crab fishery. Oyster bars and open bottoms of sand, mud, shell, and bedrock provide important habitat and food for other estuarine species. They harbor a rich macro invertebrate community that is utilized by wading birds, as well as shorebirds and fish.

In the Caloosahatchee Estuary, mangroves support fish and macro invertebrate communities by providing a protected nursery area. Important marine and estuarine species that spend part of their life cycle in the mangrove community include snook, snapper, tarpon, jack, sheepshead, red drum, ladyfish, blue crab, and shrimp. Mangrove forests also provide important foraging and nesting habitat for diverse populations of birds.

Lake Worth Lagoon

As an estuary, the Lake Worth Lagoon serves as spawning, nursery, and feeding grounds for many fish and invertebrate species. Recreational and commercial fish

species, invertebrates, birds, endangered and threatened species use the existing natural estuarine communities of the lagoon. Within Lake Worth Lagoon, seagrass communities provide critical refugia for juvenile fish such as red drum, grouper, snook, and spotted seatrout. A total of 261 species of fish have been collected in Lake Worth Lagoon, including fish species found in the vicinity of the inlets (Crigger, Graves, and Fike, 2005). The manatee uses Lake Worth Lagoon as refuge and a travel corridor. Several bird sanctuaries and rookeries are also located in the Lake Worth Lagoon (Crigger et al., 2005).

5.4.3. EVERGLADES AGRICULTURAL AREA

Wildlife habitat within the EAA is mostly limited to the canal systems. Flooded and cultivated agricultural fields attract feeding birds, especially waders. The Holey Land and Rotenberger WMAs located at the south end of the EAA support populations of wading birds, deer, hogs and waterfowl. Wading birds and some raptors also frequent the flooded fields and canals. Raptors find abundant food sources in small mammals, snakes and other reptiles, which often inhabit sugar cane fields. The extensive canal system supports fish species that normally would not be common inhabitants of the Everglades marshes, but are typically found in lakes. These fish include black crappie, catfish, and shad. Oscars (*Astronotus* spp.), spotted tilapia (*Tilapia mariae*), walking catfish (*Clarias batrachus*), and the black acara (*Cichlasoma bimaculatum*) are examples of exotic fish species that have become established within the region.

5.4.4. WATER CONSERVATION AREAS (GREATER EVERGLADES)

The WCAs as a whole contain a number of important species whose existence, population numbers and sustainability are markedly influenced by water levels. The American alligator, a keystone Everglades species, has rebounded in terms of population numbers since the 1960s when the reptile was placed on the endangered species list by the USFWS. Alligators, it is believed, play an important ecological function by maintaining "gator holes", or depressions, in the muck which are thought to provide refuge for aquatic organisms during times of drought and concentrates food sources for wading birds. High water during periods of nest construction which occurs from June to early July (Woodward et al., 1989) decreases the availability of nesting sites. If conditions become too dry, water levels may fall too low to maintain gator holes, forcing the animal to seek other areas to survive.

Other important reptile species commonly encountered within the study area include a number of species of turtles, lizards, and snakes. Turtle species include the snapping turtle (*Chelydra serpentina*), striped mud turtle (*Kinosternon bauri*), mud turtle (*K. subrubrum*), cooter (*Chrysemys floridana*), Florida chicken turtle (*Deirochelys reticularia*), and Florida softshell turtle (*Trionyx ferox*). Lizards such as the green anole (*Anolis carolinensis*), are found in the central Everglades, and several species of skinks occur more commonly in terrestrial habitats. Numerous snakes inhabit the wetland and terrestrial environments. Drier habitats support such species as the Florida brown snake (*Storeria dekayi*), southern ringneck snake (*Diadophis punctatus*), southern black racer (*Coluber constrictor*), scarlet snake (*Cemophora coccinea*), and two rattlesnakes (*Sistrurus miliarius* and *Crotalus adamanteus*). The Eastern indigo snake (*Drymarchon*

corais), a Federally listed threatened species, and the Florida pine snake (*Pituophis melanoleucus mugitus*), a State species of special concern, may also exist in drier areas of the study area. Wetter habitats support more aquatic species such as the water snake (*Natrix sipedon*), the green water snake, mud snake (*Francia abacura*), eastern garter snake (*Thamnophis sirtalis*), ribbon snake (*T. sauritus*), rat snake (*Elaphe obsoleta*), and the Florida cottonmouth (*Agkistrodon piscivorus*) (McDiarmid and Pritchard, 1978).

Important amphibians, known to occur in south Florida, include the Everglades bullfrog, or pig frog (*R. grylio*), Florida cricket frog (*Acris gryllus*), green tree frog (*Hyla cinerea*), and southern leopard frog, southern chorus frog (*Pseudacris nigrita*) and various tree frogs are common to tree islands and cypress forests. Salamanders inhabit the densely vegetated, still or slow-moving waters of the sawgrass marshes and wet prairies. They include the greater siren and the Everglades dwarf siren (*Pseudobranchus striatus*). Toads such as the southern toad (*Bufo Terrestris*), the oak toad (*Bufo quercicus*) and the eastern narrow-mouth toad (*Gastrophryne carolinensis*) also occur within the study area.

Colonial wading birds (*Ciconiformes*) are a conspicuous component of the wildlife communities that utilize the WCAs as both feeding and breeding habitat. These include 11 species of herons and egrets, two species of ibis, the wood stork, and the roseate spoonbill (Robertson and Kushlan, 1984). Historically, white ibis has been the most abundant colonial wading bird species within the WCAs. Surveys indicate that the great egret is the second most abundant species (Frederick and Collopy, 1988). The great blue heron, little blue heron, tricolored heron, green backed heron (*Butorides striatus*), snowy egret (*E. thula*), cattle egret (*Bubulcus ibis*), black crowned night heron (*Nycticorax nycticorax*), and yellow crowned night heron (*N. violacea*), are also common wading bird species found throughout the WCAs. The roseate spoonbill (*Ajaia ajaja*), a State listed species of special concern, and the wood stork, a Federally listed endangered species, both occur within the WCAs. The WCAs support additional aquatic avifauna, such as the limpkin (*Aramus guarauna*), two bitterns (*Ixobryucus exilis* and *Botarus lentiginosus*), the anhinga, as well as a number of resident and migratory waterfowl.

The Everglades fish community is composed of a variety of forage fish important in the diet of many wading birds, sport fish, native species and exotics introduced partly through aquacultural practices and the aquarium trade. Forage species include the Florida flagfish, bluefin killifish, least killifish, shiners, mosquito fish, and sailfin molly.

Generally, Everglades sport fish are harvested from the borrow canals that surround the marsh. As water levels in the canal and marsh rise, fish populations disperse into the interior marsh and reproduce with minimum competition and predation. As water levels recede, fish concentrate into the deeper waters of the surrounding canals, where they become available as prey for wildlife and fishermen. In some instances, the canal fishery has experienced major fish kills due to overcrowding and oxygen depletion. The WCAs provide a valuable sport fishery for south Florida. Many of the canals, notably

along U.S. Highway 41, I-75, and in the L-35B and L-67A provide valuable recreational fishing for largemouth bass, sunfish, oscar, gar, bowfin (*Amia calva*), catfish and other species.

Besides supporting a valuable recreational fishery for the region, fish communities in the WCAs provide a major food source for Everglades wading birds, alligators, and other carnivorous reptiles and mammals. Fish community structure and abundance is highly dependent on water levels. Consequently, fishing success by humans or wildlife is also dependent on water levels (Dineen, 1974). For a more complete listing of common Everglades fishes refer to Gunderson and Loftus (1993).

Several game and non-game wildlife species occur within the WCA system including: white-tailed deer (*Odocoileus virginianus*), common snipe (*Capella gallinago*), and marsh rabbit (*Sylvilagus palustris*). Blue-winged teal (*Anas discors*), mottled ducks (*A. fulvigula*) and other game waterfowl are found in the sloughs of the northeast corner. Feral hogs (*Sus scrofa*) may also be present in drier areas or on tree islands.

5.5. ESSENTIAL FISH HABITAT

In accordance with the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) of 1976 and the 1996 Sustainable Fisheries Act, an Essential Fish Habitat (EFH) Assessment is necessary for implementation of the Preferred Alternative. An EFH Assessment is a review of the proposed action and its potential impacts to EFH. The rules promulgated by the National Marine Fisheries Service (NMFS) in 1997 and 2002 further clarify EFH by definition as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." *Waters* include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include areas historically used by fish where appropriate. *Substrate* includes sediment, hardbottom, structures underlying the waters, and any associated biological communities. *Necessary* means the habitat required to support a sustainable fishery and managed species' contribution to a healthy ecosystem. *Spawning, breeding, feeding, or growth to maturity* covers all habitat types used by a species throughout its life cycle.

Only species managed under a federal fishery management plan (FMP) are covered under (50 CFR 600). The act requires federal agencies to consult on activities that may adversely influence EFH designated in the FMPs. The activities may have direct (e.g., physical disruption) or indirect (e.g., loss of prey species) effects on EFH and may be site-specific or habitat-wide. The adverse result(s) must be evaluated individually and cumulatively.

The St. Lucie Estuary and the Southern Indian River Lagoon are within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC) and are located in areas designated as EFH for estuarine waters, mangroves, seagrasses, and live bottom communities. The estuary provides EFH for adult and juvenile red drum (*Sciaenops ocellatus*), shrimp, spiny lobster (*Panulirus argus*), and the snapper-grouper complex.

In addition, the nearshore hardbottom habitat outside of the St. Lucie and Ft. Pierce Inlets is designated as EFH Areas of Special Concern for the snapper-grouper complex. The Caloosahatchee Estuary is within the jurisdiction of the Gulf of Mexico Fishery Management Council (GMFMC). In the estuary, EFH is defined as all estuarine waters and substrates (mud, sand, shell, rock and associated biological communities), including the sub-tidal vegetation (seagrasses and algae) and the adjacent inter-tidal vegetation (marshes and mangroves). The estuary provides EFH for adult and juvenile brown shrimp (*Penaeus aztecus*), pink shrimp (*Panaeus duorarum*), white shrimp (*Penaeus setiferus*), gray snapper (*Lutjanus griseus*), red drum (*Sciaenops ocellatus*), Spanish mackerel (*Scomberomorus maculatus*), spiny lobster (*Panulirus argus*), stone crab (*Menippe mercenaria*), and gulf stone crab (*Menippe adina*).

In conformance with the 1996 amendment to the MSFCMA, the information provided in the SEIS will comprise the required EFH Assessment. The SEIS has been coordinated with the NMFS Habitat Conservation Division which initiated consultation under the MSFCMA. A "No Objection" letter to the Corps' action was received from NMFS by letter dated July 24, 2007.

5.6. COASTAL BARRIER RESOURCES

There are no coastal barrier resources in the project study area.

5.7. FLOOD PROTECTION

One of the primary functions of the C&SF Project is to provide a highly-efficient flood control system designed to minimize flooding in the urban and agricultural areas dry in the wet season by discharging excess water to tide or into the WCAs and ENP. Flood control works on Lake Okeechobee consist of a system of about 1,000 miles of encircling levees designed to withstand a severe combination of flood stage and hurricane occurrence, plus the regulatory outlets of St. Lucie Canal and the Caloosahatchee River. The design discharge of Moore Haven Spillway is 9,300 cfs and St. Lucie Spillway is about 16,000 cfs (USACE, 1999). Following removal of local runoff from the agricultural areas south of Lake Okeechobee, an additional regulatory capability of several thousand cfs is available through the Miami, North New River, Hillsboro, and West Palm Beach Canals by pumping into the three WCAs. The crest elevation of the levee system surrounding the lake ranges from 32 to 45 ft., NGVD. Possible flooding due to overtopping of levees within the HHD system is limited to short duration events involving wave run-up in addition to hurricane-induced storm surge.

5.8. WATER SUPPLY

As one of the federally authorized project purposes, Lake Okeechobee supplies water for agricultural irrigation, municipalities, industry, and ENP, and for regional groundwater control and salinity control.

A primary use of Lake Okeechobee is to provide water supply for adjacent urban and agricultural lands and a backup water supply for lower east and west coast Florida counties. Currently, Lake Okeechobee provides a primary source of potable water to the cities of Clewiston, Hendry County; South Bay, Belle Glade and Pahokee, Palm

Beach County; and Okeechobee, Okeechobee County. The C-43 provides an important source of potable water for Lee County and the City of Ft. Myers and is also used as a source of water for irrigation by agriculture.

During dry periods, increased water usage and large dry season water losses due to evapotranspiration can result in undesirably low water levels. To reduce adverse impacts from low lake levels, water use restrictions are imposed by the SFWMD to stretch the limited supplies. If the water level at the beginning of the dry season is low, then the likelihood of water restrictions is greater. The SFWMD has a developed water shortage management plan, expected to be effective November 15, 2007, known as the Lake Okeechobee Water Shortage Management (LOWSM) Plan that requires various actions to be taken according to the severity of the actual and projected lake water levels. The basis of this plan is an allocation scheme that parcels out lake water based on a percentage of the 1 in 10 water demand. If the lake level continues to fall, the percentage of water restrictions increases. Further details are provided in Appendix G. This new plan is a modification of the original Supply-Side Management Plan, and it was effectively used during the 2006-2007 drought.

The Supply-Side Management Plan was used to manage water supplies during the 1989-90 drought and the 2000-2001 drought. This plan is no longer used in practice and is being replaced by the modified LOWSM Plan (Appendix G). Since the SSM Plan was the available plan at the time modeling began for this LORSS, the 2007 LORS simulation uses the SSM Plan as a baseline. As documented in sections 2.3 and 4.4, an earlier version of the SFWMD LOWSM water shortage management plan (different from the "modified LOWSM" plan currently proposed) was utilized for the alternative evaluations in this SEIS. Though operational details for implementation have not been finalized by the SFWMD and provided to the USACE in time for publication in the LORS Final SEIS, the water shortage rule is expected to provide water supply performance within the bracketed range that was evaluated in the LORSS draft SEIS.

The SSM Plan (Hall, 1991) defines a target water level in Lake Okeechobee for the beginning of the wet season (June 1st) and water supply allotments are computed such that the lake water levels will not fall below the stage target, assuming average climatic conditions. Operational flexibility is built into the plan to make available the special actions that proved successful during the 1989-1990 drought. Experience gained during previous droughts led to modifications to the plan which are currently contained in the modified LOWSM Plan (Appendix G).

Water supply deliveries from Lake Okeechobee for agriculture, human consumption or environmental needs are made under the State's water supply authority. The State may allocate water for municipal and agricultural water supply, to maintain appropriate salinity envelope in the estuaries, or to provide environmental releases south, or any other reasonable beneficial uses the State deems appropriate.

5.9. WATER QUALITY

Lake Okeechobee

Waters of Lake Okeechobee have been designated by the State of Florida as Class I Waters, suitable for potable water supplies, and Class III, recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife

Water quality data indicate that Lake Okeechobee is currently in a eutrophic condition, primarily due to excessive nutrient loads from the agricultural sources both north and south of the lake. Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting water quality standards or not supplying their designated uses. According to FDEP's 1998 303(d) list, the water quality of Lake Okeechobee is impaired due to phosphorus, dissolved oxygen, iron, un-ionized ammonia, coliforms and chlorides. High phosphorus concentrations resulting from human-induced hydrologic and land use modifications are the predominant reason for impairment (FDEP, 2001). The in-lake total phosphorus (TP) concentrations have doubled over the last 50-years as a result of increased inputs from the watershed (FDEP, 2001). In September 2004, hurricanes Frances and Jeanne passed just to the northeast of Lake Okeechobee producing winds in the 70 to 80 miles per hour (mph) range to the lake. Due to Lake Okeechobee's average shallow depth, wind easily affects sediment suspension. Total phosphorus concentrations climbed to levels as much as four to five times higher than normal as a result of the 2004 hurricanes (SFWMD, 2005). Total phosphorus loading to Lake Okeechobee now averages 714 metric tons per year (mt/yr) averaged over 2002-2006 (SFWMD, 2007). The high phosphorus loading rate to the lake is derived from the watershed and the phosphorus laden sediments already in the lake. This loading is more than five times higher than the TMDL of 140 mt/yr considered necessary to achieve the target in-lake TP goal of 40 parts per billion (SFWMD, 2007). A reduction in Lake Okeechobee phosphorus to a total phosphorus concentration of 40 ppb is desired, in part, to reduce the occurrence of blue-green algal blooms, and to reduce the adverse effects of phosphorus on downstream systems.

Caloosahatchee River Basin

The Caloosahatchee River/Estuary system has been altered by agricultural and urban development during the past century, and is challenged by a variety of water quality problems, including altered salinity, elevated nutrients and increased sediment loading (SFWMD, 2005). The channelized section of the river also shows degraded water quality conditions, due to agricultural inputs, as compared to tributaries lying in less developed areas of the basin.

Water quality has been a concern in the Caloosahatchee Estuary since the late 1970s and early 1980s. A waste load allocation study in the Caloosahatchee conducted by the Florida Department of Environmental Regulation concluded that the estuary had reached its nutrient loading limits as indicated by elevated chlorophyll a (Chla) and depressed dissolved oxygen concentrations (DeGrove 1981). Target concentrations for chlorophyll a (20 ug/l), TN (1.0 mg/l) and TP (0.15 mg/l) were established as upper

limits for acceptable water quality in the region of the estuary between Cape Coral and Beautiful Island. Similarly, McPherson and Miller (1990) concluded that additional nitrogen loading would result in increases in phytoplankton and benthic algae.

Doering and Chamberlain (1998) summarized water quality conditions in the Caloosahatchee Estuary, San Carlos Bay and Pine Island Sound. Compared to other Florida estuaries (Friedeman and Hand 1989) median concentrations of Chla and TSS were relatively low while median concentrations of dissolved oxygen, TN and color were relatively high. Turbidity and concentrations of TP were close to the statewide median values for estuaries. Concentrations of TN, TP and Chla that exceeded the upper limits established by DER (DeGrove 1981) occurred mainly in the upper estuary between S-79 and Ft. Myers. Although dissolved oxygen concentration were generally high in the overall system, some values at or below 2 mg/l were observed at the head of the Caloosahatchee Estuary and these occurred in the warmer months between May and October (Doering and Chamberlain 1998). Most studies conducted in the Caloosahatchee find a relatively poorer water quality in the upper estuary that improves as proximity to the ocean increases.

Freshwater discharges from Lake Okeechobee are often viewed as a main contributor of nutrient loading to the Caloosahatchee Estuary. In fact, discharges of Lake Okeechobee are just a piece of the puzzle of water quality issues in the Caloosahatchee River and estuary. While Lake Okeechobee water is extremely high in nutrient concentrations as indicated above in Section 5.9, it is only a fraction of the Total Nitrogen (TN) and Total Phosphorus (TP) loading into the Caloosahatchee Estuary. Table 5-2 is provided to summarize, by percentage, the estimated year 2000 average basin water and nutrient loads for the entire Caloosahatchee River/Estuary basin as presented by SFWMD (2005).

TABLE 5-2: ESTIMATED 2000 EXISTING WATER AND NUTRIENT LOADS WITHIN THE CALOOSAHTCHEE RIVER/ESTUARY WATERSHED BASIN BY PERCENTAGE (source: SFWMD, 2005)

Watershed Source	Annual Flow	TN (MT/yr)	TP (MT/yr)
Lake Okeechobee	31%	28%	11%
Caloosahatchee River freshwater basin	46%	50%	63%
Caloosahatchee River Estuary basin	23%	21%	26%

Water quality in the Caloosahatchee Estuary varies as a function of freshwater discharge at S-79 and source of that discharge (C-43 Basin or Lake Okeechobee). In general, the concentrations of color, and total and dissolved inorganic nitrogen in the

estuary increased as discharge at S-79 increased. When the river basin was the major source of discharge, the concentrations of nutrients (excepting ammonia) and color were relatively higher than when the Lake was the major source (Doering and Chamberlain, 1999a).

St. Lucie River Basin

Several major basin alterations have affected the water quality conditions in the St. Lucie River Basin. From opening the St. Lucie Inlet in the late 1800's to completing an extensive drainage and flood control system including the construction of the C-44 Canal which connects Lake Okeechobee to the estuary, water quality impairments are common. Alterations or modifications have increased freshwater discharges, nutrient loads and sediment deposition rates in the St. Lucie Estuary (FDEP, 2003). The Indian River Surface Water Improvement and Management Plan was issued in compliance with the Florida Surface Water Improvement and Management Act (Florida Statutes Chapter 373.451-373.4595) in 1989 and then revised and updated in 1993. The St. Lucie Estuary was identified as a priority for water and sediment quality improvement within the Indian River Lagoon watershed. Major environmental concerns within the St. Lucie Estuary were identified, namely excess nutrients and salinity fluctuations. Major water quality issues in the St. Lucie Estuary stem from high variability in salinity, frequent events of low dissolved oxygen, high nutrient concentrations and light limitation of plant growth due to high levels of humic substances and suspended solids brought into the system with the freshwater (Chamberlain and Hayward, 1996). Water quality conditions along the St. Lucie River may be considered less impaired in undeveloped areas of the basin. However, conditions are more degraded in urbanized areas along the extensive network of canals that drain this area.

5.10. HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

A preliminary assessment indicated no evidence of HTRW affecting this action.

5.11. AIR QUALITY

Clean Air Act (CAA) General Conformity Rule. Section 176(c) of the CAA requires that Federal agencies assure that their activities are in conformance with Federally-approved CAA state implementation plans for geographical areas designated as "nonattainment" and "maintenance" areas under the CAA. On 30 November 1993, EPA published its final General Conformity Rule to implement Section 176(c). EPA's final rule addresses how Federal agencies are to demonstrate that activities in which they engage confirm with Federally approved CAA state implementation plans. The EPA rule contains a number of "exempted" or "presumed to conform" activities which include a number of Corps activities. As applicable and required, CAA conformity determinations will be completed during feasibility studies and included in feasibility reports.

5.12. NOISE

Ambient noise levels are low to moderate in the Lake Okeechobee region. The major noise producing sources are vehicular and boat traffic.

5.13. AESTHETIC RESOURCES

Lake Okeechobee, the Caloosahatchee River Basin and the St. Lucie Estuary have several landscape features that are aesthetically appealing to tourists and local communities.

5.14. RECREATION RESOURCES

Lake Okeechobee and the St. Lucie and Caloosahatchee estuaries are considered popular recreational resources in south Florida. Fishing, recreational boating, sightseeing, wildlife watching, camping and swimming are just a few of the recreational activities in which residents and visitors participate. Lake Okeechobee is host to more than 500 permitted bass fishing tournaments annually and ranks as the top bass fishing lake in the U.S. (Havens, et al., 2004a).

5.15. NAVIGATION

A navigable waterway exists from the Intracoastal Waterway at St. Lucie Inlet on the Atlantic Coast across the State by way of St. Lucie Canal, Lake Okeechobee, and Caloosahatchee River to the Gulf of Mexico. The Caloosahatchee River is the western navigational channel for the Okeechobee Waterway. When the Lake Okeechobee stage is below 12.56 ft., NGVD, the authorized project depth is not maintained. The waterway consists of 154 miles of navigation channel, including Lake Okeechobee. Commercial and recreational navigation via the Okeechobee Waterway takes advantage of this shortcut across the Florida peninsula.

5.16. HISTORIC PROPERTIES

This action was coordinated in accordance with Section 106 of the *National Historic Preservation Act* (NHPA) of 1966, as amended, and 36 CFR, Part 800: *Protection of Historic Properties*. The State Historic Preservation Officer (SHPO) advises and assists the Corps in identifying historic properties (archaeological, architectural, and historical) listed, or eligible for listing, in the *National Register of Historic Places*, assessing the project's effects, and considering alternatives to avoid or minimize effects.

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6. ENVIRONMENTAL EFFECTS

This section is the scientific and analytic basis for the comparisons of the alternatives. See Table 2-1 in Section 2.0 Alternatives, for summary of impacts. The following includes anticipated changes to the existing environment including direct, indirect, and cumulative effects.

6.1. GENERAL ENVIRONMENTAL EFFECTS

6.2. VEGETATION

6.2.1. LAKE OKEECHOBEE

Extreme High

At the extreme high stage (>17 feet), it has been documented that wind driven waves can cause large-scale loss of submerged and emergent plants by physical uprooting (Havens et al., 2004c). Reduction in the duration and severity of high water stages is expected to be more favorable for maintenance of more diverse vegetative communities in the littoral zone, which in turn should provide for more favorable habitat conditions for fish and wildlife. The anticipated overall increase in diversity of littoral vegetation is expected to include larger areas vegetated by willow, which has been adversely impacted through the years by prolonged high water elevations. Willow is important nesting substrate for wading birds and the endangered snail kite. Very high water levels are also destructive to apple snail habitat. Emergent vegetation is important for the apple snail, because the snail must breathe air. Snails need to climb the plant stems to breath air, and they need the portion of the stems to remain above water level for their eggs to hatch (USFWS, 2007).

More extreme high water stages (>17 feet) would be significantly reduced under the Preferred Alternative, or any of the alternatives, compared to the No Action Alternative, thereby decreasing the likelihood of erosion of bulrush and other emergent vegetation from the deep water edge of the littoral zone. Decreasing high water stages would encourage healthy growth of plants and vegetative recruitment. Lake scientists agree that even prolonged periods of moderately high lake levels are known to impact marsh vegetation. When lake stages exceed 15 feet for long periods, especially when light penetration is inhibited by turbid water, adverse impacts to SAV can occur. Modeling simulations indicate that the No Action Alternative had two events of lake stage >15 feet for 365 days. All other alternatives have zero events. As the past has shown, even moderate high lake levels (>15 feet) of prolonged (>12 months) duration, may cause significant harm to Lake Okeechobee's ecosystem. All of the alternatives did equally well with reducing lake stages >17 feet. The No Action Alternative performed the worst for this PM.

Extreme Low

The extreme low stage, identified at ten feet, is the depth at which substantial adverse effects on Lake Okeechobee may occur. It is at this depth where detailed field observations during the 2000-2001 drought indicated that adverse effects such as rapid spread of terrestrial weedy plants, severe loss of SAV and loss of apple snail population, occurred. Even when the lake stage falls below 11 feet, the entire littoral zone is dry (Havens and Gawlik, 2005).

As would be expected, alternatives that did the best in reducing extreme high lake stage occurrences did worse at reducing extreme low lake stage occurrences. The No Action Alternative has fewer low lake stage events than the other alternatives, as would be expected since it has more high lake stage events. The remainder of the alternatives scored relatively the same for lake stages less than (<) ten feet. All of the alternatives will have more low stage events compared to the No Action Alternative. However, the positive ecological effect of alternatives lowering the lake stage to reduce the high extreme events potentially out weights the possible adverse ecological effects of occasional extreme low water events.

Even though adverse effects occur during low lake stages, there are a number of benefits to the ecosystem that also occur, such as drying and oxidation of accumulated organic detritus in the littoral zone, favorable conditions for marsh fires that burn away cattail and torpedograss thatch, and exposure of moist soil for plant germination (Havens et al., 2004c).

Stage Envelope

Although the stage envelope is optimal for Lake Okeechobee, it is also necessary for the system to occasionally experience the extreme highs, and particularly the extreme lows, which would mimic more natural conditions. In Lake Okeechobee, water level management that mimics natural conditions will have the greatest benefits to plant communities (FFWCC, 2003).

A water management regime similar to the Lake Okeechobee Stage Envelope PM, where water levels are between 12.5 feet (June-July low) and 15.5 feet (November-January high), is the target range for the Preferred Alternative. A wide body of published research documents the benefits of variable water levels within this range (Havens & Gawlick, 2005; FFWCC, 2003; Smith, et al., 1995; Aumen and Gray, 1995). A January to June stage recession would provide benefits for wading birds nesting and foraging, development of good submerged and emergent vegetation habitat for fish and wildlife, and in general, benefits the littoral wetland by providing a range of water depths that subject most of that area to wetting and drying (Havens et al., 2003c). Although these conditions are beneficial, they should not be repeated every year. Lake Okeechobee experts recognize that there should also be years of extreme stage, especially stages below 11 feet that are needed to periodically dry out lower elevation littoral areas so they can benefit from detritus oxidation and fires (Aumen and Gray, 1995; Havens et al., 2004c).

All alternatives performed basically the same for the percentage of time within the stage envelope as indicated in Table 6-1. The differences within the stage envelope were minor with the No Action Alternative falling within the stage envelope 27.52 percent of the time and the Preferred Alternative falling within the envelope 25.26 percent of the time. The remaining alternatives fell somewhere in between these scores.

Due to the small differences in the performance of Alternatives A through E, it is unclear whether one alternative is significantly better for lake vegetation or lake ecology in general. The differences are indistinguishable from each other in their potential ecological effect on Lake Okeechobee.

TABLE 6-1: LAKE OKEECHOBEE ECOLOGICAL PERFORMANCE

ALTERNATIVE	Hi Events above 17 ft.	Low Events below 11 ft.	# of times lake stage is >15 ft. for >365 days	Low stage <11 ft for >80 days	% of time w/in Stage Envelope
No Action	11	11	2	5	27.5
Alt A	4	20	0	6	26.6
Alt B	2	21	0	7	27.0
Alt C	2	17	0	8	27.3
Alt D	3	19	0	6	25.4
Alt E (Preferred)	2	23	0	6	25.3

6.2.2. ESTUARINE VEGETATION AND OYSTERS

Releases of freshwater from Lake Okeechobee along with other tributary inflows and stormwater runoff can cause large fluctuations in salinity. These fluctuations often expose estuarine biota to salinities that are outside of their tolerance ranges. Alternatives that maintain flows (and hence estuarine salinities) within acceptable limits are best for estuarine health. However, it is important to note that the hydrologic model output assumes maximum practicable releases from Lake Okeechobee within each decision tree zone or band, with consideration of downstream operational constraints. This provides a very useful means for comparing the effects of all alternatives. However, the decision making process to determine quantity, timing, and duration of the potential release considers estuary conditions/needs, potential impacts from lake releases, local runoff, and dry weather conditions. Although modeled and represented in the modeling output, maximum releases are not always necessary or recommended during actual lake operations.

Caloosahatchee Estuary

Salinity tolerances of submerged grasses are used as performance indicators to identify minimum and maximum inflows from S-79. Mean monthly flows less than 450 cfs are thought to allow salinity in the upper estuary to exceed the tolerance of tape grass (SFWMD, 2003). Flows greater than 2800 cfs depress salinity in the lower estuary and

threaten the marine shoal grass typical of this region (Doering, et al., 2002). Mean monthly flows greater than 4500 cfs depress salinity in San Carlos Bay and threaten turtle grass beds typical of this region (SFWMD, 2003).

Low Flow

Alternatives with the lowest occurrences of mean monthly flows below the low flow limit of <450 cfs are better. As indicated in Table 6-2, Alternatives A through E provide significant relief from low (<450 cfs) mean monthly flows as compared to the No Action Alternative.

TABLE 6-2: CALOOSAHATCHEE MEAN MONTHLY FLOWS				
Alternative	CFS at S-79			
	<450	450-2800	2800-4500	>4500
No Action	198	160	45	29
Alt A	104	260	32	36
Alt B	105	257	35	35
Alt C	116	247	35	34
Alt D	131	238	34	29
Alt E (Preferred)	131	237	35	29

High Flow

High flow is measured by occurrences of mean monthly flows greater than 2800 cfs, as measured at the S79, from Lake Okeechobee regulatory releases in combination with flow from the Caloosahatchee River (C-43) basin. Alternatives with the least occurrences in the high flow range are considered better. Alternatives A through E reduce the months of flows between 2800–4500 cfs. Only Alternatives D and E equaled the No Action Alternative in the >4500 cfs flow class. Alternatives A, B and C had a greater number of months in the >4500 cfs flow class compared to the No Action Alternative.

Acceptable Flow

Alternatives A through E had a significantly greater number of months in the acceptable flow range of 450-2800 cfs as indicated in Table 6-2.

Base Flow

The preferred alternative schedule has a base flow band included in the schedule which would be beneficial for the Caloosahatchee Estuary. When the schedule is in the base flow band, low-volume releases can be made to the estuary. Base flow limits are defined at up to 450 cfs measured at S-79. If the basin runoff between Lake Okeechobee and the estuary is less than this "base flow", then Lake Okeechobee releases are made to supplement the difference. These base flow releases of excess lake water may have environmental benefits to the estuaries by providing flow when the upper estuary is experiencing too much salinity, and assist in reducing the chances of subsequent high volume discharges. Allowing base flow (freshwater releases) when the upper estuary is experiencing excessive salinity is a benefit to freshwater species

such as tape grass. Tape grass is also important upper estuary habitat for a variety of freshwater and estuarine invertebrate and vertebrate species. During times of extended low inflow conditions, when salinity is too high in the upper estuary, tape grass may be adversely affected, as well as the animal species utilizing the grass habitat.

Duration of High Flows

All alternatives had high flows (>4500 cfs) of longer duration than the No Action Alternative (Table 6-3). This was reflected in the total number of weeks of high flows greater than five weeks and at times, Alternatives B and C, had very long duration flows in the 13 to 16 week range. The No Action Alternative had the fewest number of weeks of high flow greater than five weeks. Of Alternatives A through E, Alternative E had the fewest number of weeks of high flow greater than five weeks. The long duration flows >4500 cfs are more likely to affect the lower estuary from Shell Point to San Carlos Bay, including the J.N. Ding Darling NWR. When the high flow events increase substantially in duration, impacts to the lower estuary can be more adverse. Oysters and seagrasses may be negatively affected. These sessile species cannot move to areas of preferred salinity ranges although they can tolerate low salinity levels for short durations. These species become more susceptible to disease and predation as the duration of extreme high flow events increase.

TABLE 6-3: CALOOSAHATCHEE ESTUARY: DURATION

	Weekly Moving Avg >4500 cfs				Sum
	13-16 wk	10-12wk	8-9 wk	6-7 wks	
No Action	0	20	8	0	28
Alt A	0	42	26	20	88
Alt B	13	42	16	12	83
Alt C	13	21	26	6	66
Alt D	0	31	16	32	79
Alt E (preferred)	0	32	8	25	65

St. Lucie Estuary

Like the Caloosahatchee Estuary, similar ecological problems exist in the St. Lucie Estuary. Maintaining a favorable salinity envelope within the estuary will benefit oysters and SAV. Although estimates of oyster salinity tolerance vary in the literature, a range of approximately 8-25 ppt appears tolerable, with a higher minimum (10-12 ppt) required for larval development. Although SAV coverage within the St. Lucie Estuary is limited, SAV that have the greatest potential to flourish in the shallow, inter to outer estuary waters are wild celery (*Vallisneria americana*), widgeon grass (*Ruppia maritima*), and shoal grass (*Halodule wrightii*). The salinity requirements to maintain persistent SAV beds of these species are 0 to 10 ppt, 5 to 15 ppt, and 22 to 38 ppt, respectively (Haunert and Konyha 2004). Mean monthly total inflows in the 2000–3000 cfs ranges result in low, damaging salinities throughout the St. Lucie Estuary adversely impacting

oyster beds. Flows greater than 3000 cfs may adversely affect more marine waters in the Indian River Lagoon and the seagrasses residing there.

Low Flow

Alternatives with the lowest occurrences of mean monthly flows below the low flow limit of <350 cfs are better. As indicated in Table 6-4, Alternatives A through E provide significant relief from low (<350 cfs) mean monthly flows as compared to the No Action Alternative.

TABLE 6-4: ST. LUCIE MEAN MONTHLY TOTAL FLOWS				
Alternative	CFS			
	<350	350-2000	2000-3000	>3000
No Action	127	231	43	31
Alt A	129	237	36	30
Alt B	129	238	38	27
Alt C	123	244	37	28
Alt D	103	254	44	31
Alt E (Preferred)	103	256	42	31

High Flow

When examining the distribution of mean monthly flows for the entire POR, only Alternative D did worse (by 1-month) at reducing high flows >2000 cfs, when compared to the No Action Alternative. All other alternatives showed at least minor improvement in reducing flows >2000 cfs (Table 6-4). The preferred alternative only improves high flows >2000 cfs by 1-month. To the extent that the Preferred Alternative is able to reduce high freshwater flows to the estuary and Indian River Lagoon system, it will benefit SAV, including seagrasses which are currently in a declining state from sediment and nutrient deposition from upstream sources. Clearer water and more stable salinity are expected to foster re-colonization of the bottom by benthic plants, especially shoal grass.

Acceptable Flow

All alternatives improve flows in the preferred or tolerable range between 350–2000 cfs, with Alternative E, the Preferred Alternative, performing the best.

Base Flow

The preferred alternative schedule has a base flow band included in the schedule which would be beneficial for the St. Lucie Estuary. When the schedule is in the base flow band, low-volume releases can be made to the estuary. Base flow limits are defined at up to 200 cfs measured at S-80. Unlike the Caloosahatchee Estuary, base flow to the St. Lucie Estuary would not be necessary for providing freshwater flow for high salinity conditions. However, the base flow would assist in reducing the chances of subsequent high volume discharges to the estuary.

Duration of High Flows

All alternatives had high flows of longer duration than the No Action Alternative (Table 6-5). The 14-day moving average total inflow exceeded 3000 cfs for more than ten weeks (five two-week periods) in Alternatives A through E. The No Action Alternative had no such occurrences. When the high flow events increase substantially in duration, impacts to the estuary can be more adverse. Oysters and seagrasses may be negatively affected. These sessile species cannot move to areas of preferred salinity ranges although they can tolerate low salinity levels for short durations. These species become more susceptible to disease and predation as the duration of extreme high flow events increase.

TABLE 6-5: ST. LUCIE ESTUARY: DURATION OF HIGH FLOWS

	2 week Moving Avg >3000 cfs			Sum
	>5 periods	4-5 periods	2-3 periods	
No Action	0	13	25	38
Alt A	7	12	16	35
Alt B	8	12	14	34
Alt C	7	13	15	35
Alt D	8	12	16	36
Alt E (preferred)	8	12	16	36

Lake Worth Lagoon

Altered estuarine salinity has resulted in declines of SAV in the Lake Worth Lagoon. Maintaining the balance of freshwater discharges into the lagoon similar to those discussed for oysters in Section 6.4.2 would also benefit the potential growth of seagrasses. The differences between the alternatives were so minimal, that it would be difficult to discern any ecological consequences if one alternative was selected over another.

Estuarine Mangroves

As described in Sections 5.4.2, 5.2.3 and 5.2.4, mangroves are found along the shorelines of the northern estuaries. Urbanization/shoreline development has resulted in an extensive loss of these mangrove communities. The salinity balance needed for mangroves varies among species. Each mangrove species has a different level of salt tolerance, which in part determines its location in tidal zones. Mangroves are highly dependent on freshwater runoff to maintain an optimum salinity balance. Changes in freshwater discharges to the estuaries from any of the alternatives would not be substantial enough to cause adverse effects to mangroves in any of the estuaries within the study area. The Preferred Alternative schedule would benefit mangroves as well as SAV because it provides the ability to make long-term, low volume releases to the estuaries, when the estuaries would benefit from such releases. The intent of the

releases is to maintain desired salinity in the estuaries, and reduce the potential for future prolonged high-volume releases that may be undesirable for estuary vegetation.

6.2.3. EVERGLADES AGRICULTURE AREA

Under any of the alternatives, regulatory discharges from Lake Okeechobee will be confined to existing canal systems and flow through the EAA without impacting existing vegetation. Furthermore, native vegetation, within remnant wetlands and within the Rotenberger and Holey Land WMAs will not be impacted.

6.2.4. WATER CONSERVATION AREAS (GREATER EVERGLADES)

Peat dry-out, total weeks: Peatlands require constant inundation in order to survive. They form under constant inundation so constant saturation is essential to their existence. In addition to damaging the ecosystem, peat dry-out increases the frequency and severity of peat fires, which cause even more damage to the wetlands. Peat fires differ from surface fires, from which vegetation recovers quickly. Peat fires eliminate plant roots and the peat. Evaluation is based upon the sum of the number of weeks (in all Indicator Regions) that water depths were -1 foot or more below the surface. The target is to reduce the weeks of very low water tables to reduce the risk of peat fires and related damage to the peat.

Because all alternatives increase the number of weeks of peat dry-out, the No Action alternative is preferred.

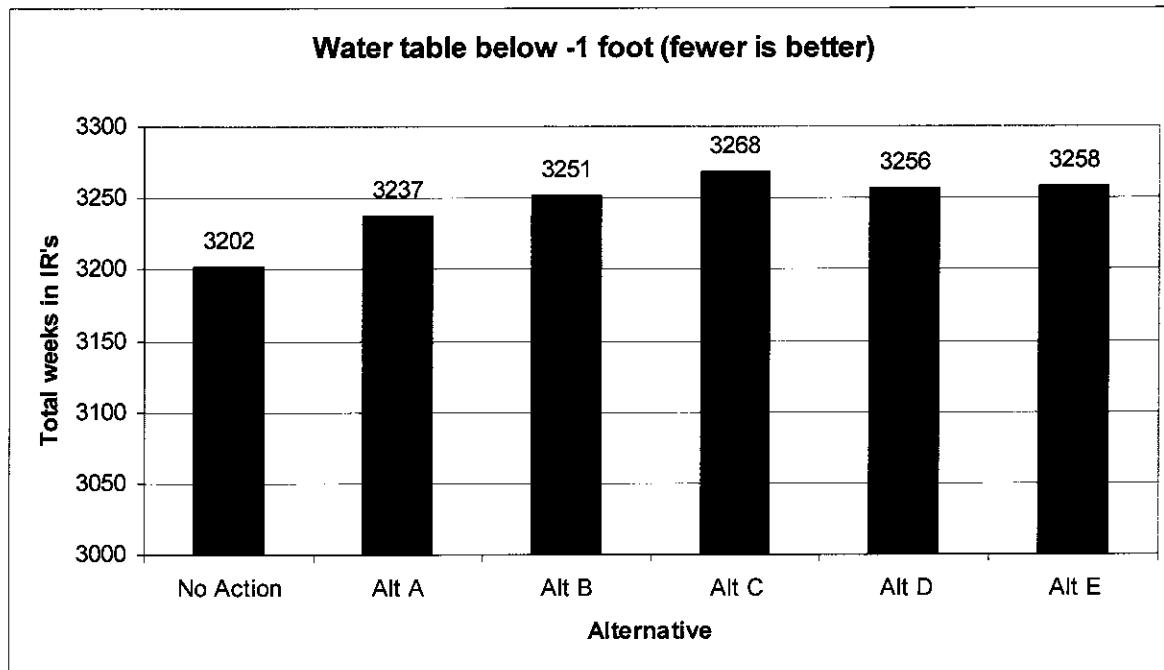


FIGURE 6-1: WEEKS OF PEAT DRY OUT OVER 36-YEAR SIMULATION PERIOD

Tree island inundation: As wetland species, trees on tree islands are accustomed to long periods of inundation. However, excessive inundation can reduce the survival of tree species, particularly when excess inundation periods occur several years in a row. The Tree Island Inundation Performance Measure records the duration in weeks (summed over all Indicator Regions) of water depths above 1.5', 1.75', 2.0', or 2.5', depending on the specific area of the Everglades (high water depth criteria for Indicator Regions 115, 116, 140, 141, 148 are 2.0'; for IRs 143 and 147 are 1.5'; for IRs 160 and 170 are 1.75'; and all others are 2.5'). Inundation should not exceed 17 weeks per year.

In these simulations, the Indicator Regions that exceed this 17 week inundation do not change in any of these scenarios. Therefore, although the total number of weeks of inundation varies, none of these differences is significant and all alternatives are equivalent for tree island inundation.

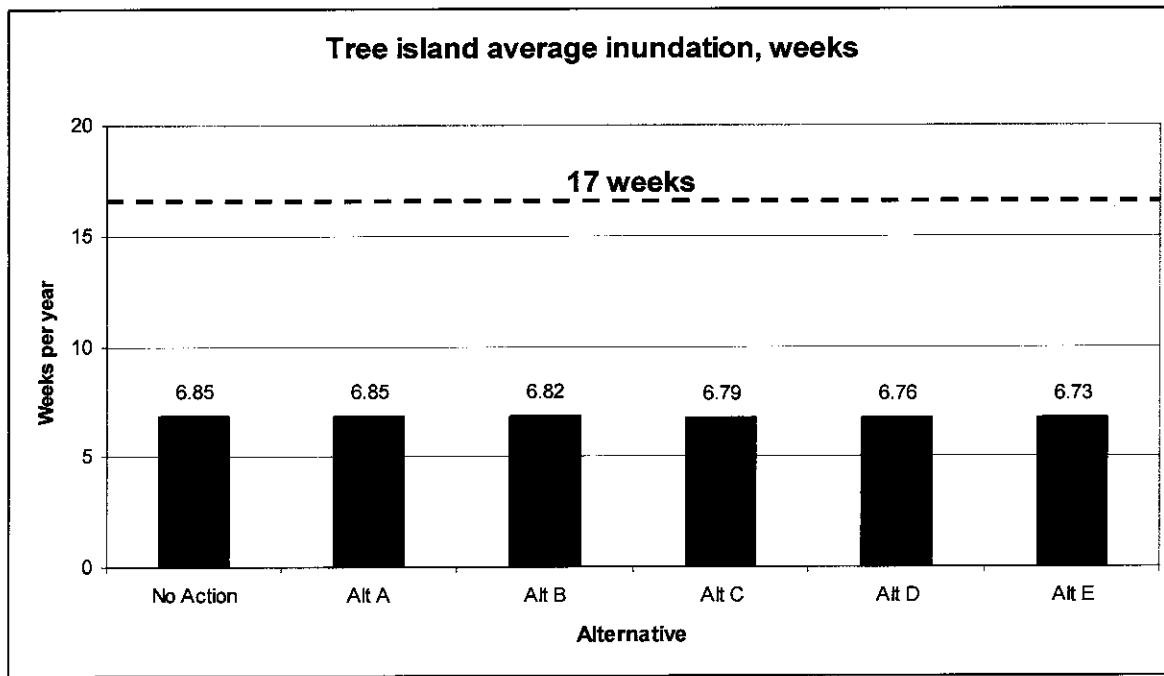
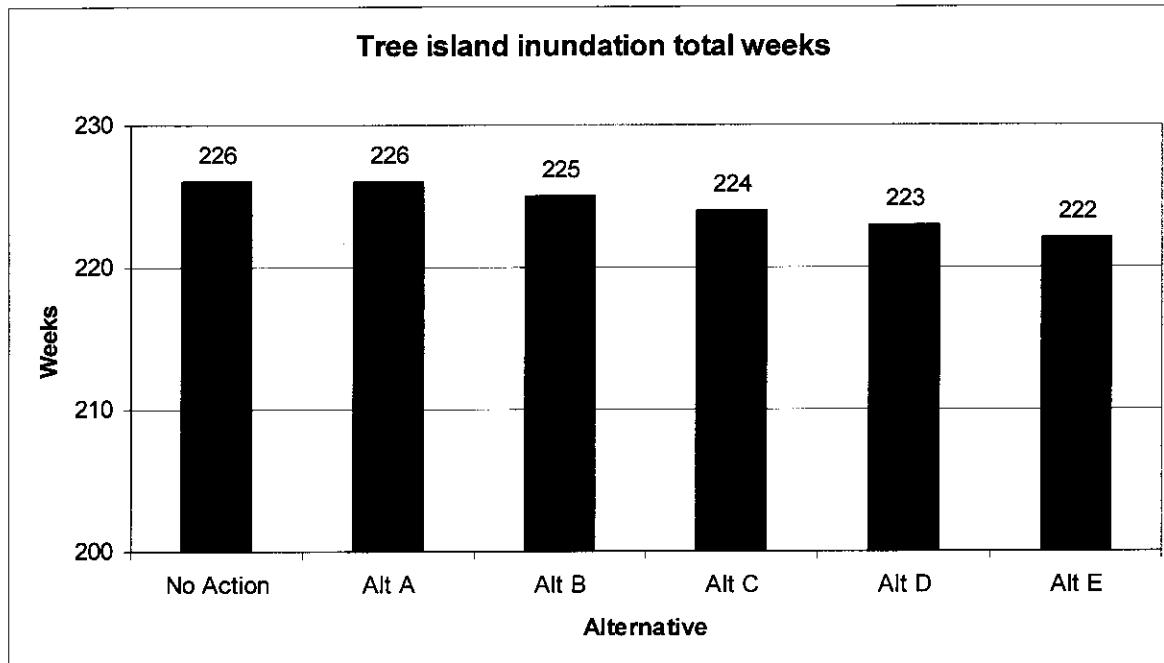


FIGURE 6-2: TOTAL WEEKS OF TREE ISLAND INUNDATION (NONE EXCEED 17 WEEKS PER YEAR AVERAGE)

6.3. THREATENED AND ENDANGERED SPECIES

Formal consultation in accordance with the Endangered Species Act (ESA) included submittal of an initial Biological Assessment (BA) to the USFWS on June 30, 2006. Updated information and a subsequent revised BA was sent to USFWS on December

15, 2006, following selection of a new alternative. The updated information did not change the Corps' original effect determinations. A Biological Opinion dated October 2007 is included in the FEIS.

The Corps initiated consultation with NMFS by letter dated August 10, 2006. The draft SEIS constituted as the BA for Johnson's seagrass on the east coast, and smalltooth sawfish on the west coast. The NMFS replied by letter dated September 27, 2006 that additional information was needed for evaluation of the Preferred Alternative. The Corps responded to the NMFS need for additional information by addressing their comments within the revised draft SEIS, and by separate cover letter. The NMFS concurred by letter dated September 11, 2007 with the Corps' determination of "may affect, not likely to adversely affect" Johnson's seagrass and the smalltooth sawfish.

6.3.1. EVERGLADE SNAIL KITE

No Action Alternative

The issue of high water levels and the detrimental effects on the littoral zone of Lake Okeechobee has been a major concern since the 1990s, and a major focus of the LORSS. The littoral zone of Lake Okeechobee provides one of the largest habitats in south Florida for the snail kite (Bennetts and Kitchens, 1997) and it supports large populations of wading birds (Smith et al., 1995). High water effects result in declines of submerged plants, as well as loss of bulrush and other emergent vegetation, where apple snails (main food source for the snail kite) lay their eggs.

Under the No Action Alternative, during abnormally wet periods of heavy rainfall and runoff, Lake Okeechobee would continue to experience high stages >16 feet, NGVD, and extreme high lake stages >17 feet, NGVD. During periods of extreme high lake levels (>17 feet), wind and erosion cause emergent and submerged plants to be torn loose from their substrate, resulting in a loss of important fish and wildlife habitat. When compared to the other alternatives, the No Action Alternative ranks the worst for high lake stage events, and is the only alternative with prolonged periods of moderately high lake stages (>15 feet for 365 days). Prolonged inundation of the littoral zone by stages >15 feet under the No Action Alternative reduces diversity of marsh vegetation on which that species depends. This alternative would continue to allow high lake stages which could adversely affect the Everglade snail kite.

As would be expected, since the No Action Alternative performs the worse for high lake stage events, it out performs the other alternatives for frequency of low lake stage events. As described in Section 5.3.1, prolonged extreme low lake events could be adverse for the snail kite's forage and nesting habitats, and may have adverse effects of the apple snail population. The No Action Alternative as modeled has 11 days of low stage events <11 feet.

Alternatives A through E

All of the alternatives performed essentially the same for percent of time within the stage envelope of 12.5 feet (June-July low) and 15.5 feet (November–January high). Habitat for the snail kite is expected to improve with a water management regime that

mimics more natural hydrologic variability. Alternative C ranks the best with 27.3 percent of time in the stage envelope, and Alternative E ranks slightly less at 25.3 percent (Table 6-1). A wide body of published research documents the benefits of seasonally variable water levels within this range for the benefit of many plants and animal communities on Lake Okeechobee.

Alternatives A through E were developed to manage Lake Okeechobee at lower elevations, reducing the frequency of high lake stage events. Alternatives A through E reduce the frequency of events >17 ft. According to Bennetts and Kitchens (1997), snail kites nest primarily in willow and other woody vegetation types. One factor contributing to loss of this habitat in Lake Okeechobee includes prolonged periods of deep water. Compared to the No Action Alternative, which has 11 events where the lake stage is above 17 feet, Alternatives A through E reduce these events considerably as indicated in Table 6-1.

Extreme low lake stage is defined by the technical experts to be a depth below ten feet. It is at this level that detailed field observations during the 2000-2001 drought indicated that negative effects (rapid spread of terrestrial weedy plants, loss of nearly all the submerged vegetation habitat and loss of the apple snail population) occurred. These extreme low conditions could impact nesting and foraging habitat for the snail kite. Macro-invertebrates such as the apple snail are impacted by extreme low water levels due to effects on plant habitat. Because snail kites feed almost exclusively on the apple snail, *Pomacea paludosa*, their survival depends directly on the hydrologic functioning of watersheds (Bennets et al., 1998). Apple snails require water levels above ground surface in order to produce egg clusters, and newly hatched snails are less able to survive dry periods than are adult-sized snails (Darby 2003). Darby (2003) has documented a peak in apple snail egg cluster production in March-April and has suggested that dry-outs below ground level prior to or during this peak can substantially reduce apple snail populations through reduced egg cluster production and reduced hatchling survival. Lake Okeechobee would experience increased number of low lake stage events under alternative A through E, with Alternative E (Preferred Alternative) having slightly more events below 11 feet (Table 5-1). The PM shown in Table 6-1 (<11 feet for >80 days) is useful for comparing the alternatives with regard to apple snail effects. Events below 11 feet are not necessarily negative for the snail kite, unless the duration of this event is prolonged, or occurs during the peak period of apple snail egg production, or during the peak of snail kite nesting. A prolonged period of extreme low stage in 2000-2001 appeared to have nearly eliminated the apple snail population from Lake Okeechobee's littoral zone (Havens and Gawlick, 2005). Additionally, if water recedes too quickly during snail kite nesting season, there is a chance for nest collapse and/or nest predation.

Alternatives A through E may have some negative effects on the snail kite and its critical habitat due to low lake stage occurrences; however, it is expected that the overall effects of implementing any of these alternatives over the No Action Alternative would be beneficial to the species.

For snail kite effects in the greater Everglades, refer to Section 6.4.4.

6.3.2. WOOD STORK

The quality of foraging habitat within Lake Okeechobee is expected to improve as a result of lower lake levels and a more natural hydrologic variability (moderately declining water levels during the wading bird nesting season) achieved by all alternatives compared to the No Action Alternative. Wood storks are also found within other areas of the LORSS region such as greater Everglades and along the Caloosahatchee River and St. Lucie canal.

Alternatives A through E may affect the wood stork, but beneficial effects are expected for this species. The No Action Alternative would continue to allow high lake levels, adversely impacting Lake Okeechobee's littoral zone that the wood stork utilizes.

6.3.3. WEST INDIAN MANATEE

As described above for the snail kite, all alternatives, except the No Action Alternative, would be beneficial for Lake Okeechobee's littoral zone plant and animal communities. All alternatives, except the No Action Alternative, would reduce the frequency of high water levels that have been detrimental over the years to Lake Okeechobee's resources. If littoral zone improvements are achieved, then there is the potential for an increase in the vegetative community on which the manatee feeds. There would be no significant adverse effect on habitat conditions for the manatee within Lake Okeechobee as a result of any of the alternatives.

The Caloosahatchee River Estuary also serves as critical habitat for the manatee. The Caloosahatchee National Wildlife Refuge located adjacent to I-75 on the Caloosahatchee River and the Ding Darling Wildlife Refuge at Sanibel Island, along with many other coastal areas in the study area, serve as a refuge and provide suitable habitat for the manatee. Based on the evaluation and discussion in Section 6.2, Northern Estuaries, it has been determined that the Preferred Alternative provides significant improvements to the estuaries in the number of months in the acceptable flow range. Similarly, the Preferred Alternative is equal to or better than the No Action Alternative in reducing the number of high flow releases from Lake Okeechobee. As such, there would be no effect on the manatee or its critical habitat from the Preferred Alternative.

6.3.4. BALD EAGLE

UPDATE: When the draft revised SEIS was prepared in early June 2007, the bald eagle was listed as threatened by the USFWS and the FFWCC. Since release of the draft, on June 28, 2007, the Secretary of the Interior announced the removal of the bald eagle from the list of threatened and endangered species. Even though they are delisted, bald eagles are still protected by the Migratory Bird Treaty Act and the Bald Eagle Protection Act.

The potential improvement to conditions of Lake Okeechobee's littoral zone may result in enhanced productivity of fish in the lake. Additionally, potential improvements to the

coastal estuaries may result in enhanced productivity of fish. As such, foraging conditions may be slightly improved for the eagle for all alternatives compared to the base. It is determined that the Preferred Alternative, or any of Alternatives A through E, would have no effect on the bald eagle.

6.3.5. EASTERN INDIGO SNAKE

The Eastern indigo snake occurs primarily on uplands. Implementation of any of the alternatives, including the No Action Alternative, would not affect the Eastern indigo snake.

6.3.6. CAPE SABLE SEASIDE SPARROW

The modeling simulations indicate that the hydrology of the indicator regions of the Everglades corresponding to occupied CSSS habitat is not adversely affected by the No Action Alternative or Alternatives A through E. Therefore, neither the species nor its designated critical habitat would likely be affected by these alternatives.

6.3.7. OKEECHOBEE GOURD

The Okeechobee gourd would benefit from any of the alternatives, except the No Action Alternative, as all of the alternatives lower the high lake stages. By decreasing the high stage events, Alternatives A through E would allow for more low lake stage events. As such, there would be a potential benefit to listed species, such as the Okeechobee gourd, where a lower lake stage is crucial for its survival. Low lake stages allow for suitable habitat areas within the littoral zone that are able to dry out and allow for seed germination. Implementation of the Preferred Alternative or any of the described alternatives may affect the gourd; however, the reduction of extreme high water under these alternatives would be beneficial overall to this species.

6.3.8. SMALLTOOTH SAWFISH

Since the Florida smalltooth sawfish population is currently restricted to waters of southwest Florida, releases from Lake Okeechobee to the St. Lucie Estuary will not affect this species. It would be more common for the smalltooth sawfish to be found along the coastal areas of the Caloosahatchee Estuary, or near the mouth of the Caloosahatchee River. Some research and monitoring in the Charlotte Harbor estuarine system is currently being conducted by the FFWCC. In studies documenting occurrences of sawfish along the southwest coast of Florida, anglers have reported encountering sawfish on a regular basis in the Charlotte Harbor area, and near the mouth of the Caloosahatchee River (Seitz and Poulakis, 2002). As part of the Charlotte Harbor study, the FFWCC is currently conducting monthly random sampling for sawfish in the Caloosahatchee River (FFWCC, 2005).

It has been documented that juvenile sawfish use shallow habitats with a lot of vegetation, such as mangrove forests and SAV, as important nursery areas. Although the studies referenced in this EIS did not document information on salinity, species distribution maps showed no occurrences in areas of permanent freshwater and many occurrences in estuarine areas. Simpfendorfer and Wiley (2005) reported that the smalltooth sawfish is likely to occur in freshwater only in estuarine areas that are

receiving high levels of freshwater input and so are temporally fresh. Simpfendorfer and Wiley (2005) concluded that further study will be required to determine the tolerance of the smalltooth sawfish to freshwater and whether long-term exposure to very low salinities or freshwater leads to changes in distribution. Since minimal information is known at this time about the salinity tolerance levels of the smalltooth sawfish and how salinity levels affect this species, the Corps has determined that the proposed alternative regulation schedule would not likely adversely affect the sawfish. A more stable salinity regime under the Preferred Alternative may result in increased SAV coverage, and therefore increase the population of small fish and benthic organisms, which are a food source for the smalltooth sawfish.

6.3.9. JOHNSON'S SEAGRASS

One of the objectives of this study is to reduce high regulatory releases to the St. Lucie Estuary, and thereby improve the salinity regime to the area. As discussed in Section 6.2, the Preferred Alternative has the highest number of months of any alternative in the acceptable flow range of 350 cfs to 2000 cfs. This is a significant improvement with the performance for the St. Lucie Estuary. Mean monthly total inflows in the 2000–3000 cfs range are known to result in low salinities throughout the St. Lucie Estuary, with flows greater than 3,000 cfs potentially causing impact to marine waters in the Indian River Lagoon. The Preferred Alternative improves flows greater than 2,000 cfs by one month over the POR, as compared to the No Action Alternative. This one-month decrease in high flow events is minor; however, when focusing in on the mean monthly flows during March through June (critical spawning time in estuary) the Preferred Alternative outperformed the No Action Alternative by having seven fewer months greater than 2000 cfs.

The decreased freshwater discharges from Lake Okeechobee would cause less stress to seagrasses, including Johnson's seagrass, in the Indian River Lagoon. As such, the Corps has determined that the Preferred Alternative, Alternative E, is not likely to adversely affect Johnson's seagrass, or critical habitat for Johnson's seagrass.

6.3.10. STATE LISTED SPECIES

Of the State listed species not evaluated above, the American alligator, brown pelican, and black skimmer (species of special concern) may slightly benefit from the Preferred Alternative by the improved fish production in Lake Okeechobee, which those species consume. The wading birds, roseate spoonbill, limpkin, little blue heron, reddish egret, snowy egret, tricolored heron, and white ibis, may benefit by the improved spring water recession regime.

6.4. FISH AND WILDLIFE RESOURCES

The effects analysis for fish and wildlife resources overlaps, or compliments, the effects on vegetation in Section 6.2. To avoid duplication of analysis, refer to Section 6.2 for additional information on fish and wildlife resources.

6.4.1. LAKE OKEECHOBEE

Although the pelagic zone of Lake Okeechobee is important in supporting commercial and recreational fisheries, the littoral zone of Lake Okeechobee is highly productive, sustains a greater diversity of fish and wildlife, and is the area most affected by changes to the LORS. Lake Okeechobee's littoral zone provides critical habitat for fish and wildlife, including Federal listed species as described in Section 6.3. A general understanding of how fish and wildlife respond to changes in habitat structure and resource availability leads to a consensus among experts that Lake Okeechobee's fish and wildlife may be harmed by extreme high and low stage events (Havens et al., 2004c; FFWCC, 2003).

The extreme water levels can completely dry out or inundate Lake Okeechobee's entire littoral zone. The current LORSS focused on alternatives that would allow lower occurrences of extreme high water events, since high water levels have been a major concern since the 1990s due to the detrimental effects on the ecology of Lake Okeechobee. Scientists observed a large-scale loss of aquatic vegetation and impacts to fisheries in Lake Okeechobee when high water conditions persisted from 1995 to 1999 (Havens, et al., 2001). Greater water depths have devastated woody plants, and submerged and emergent macrophytes, resulting in habitat destruction and alteration of primary production in the Lake Okeechobee ecosystem (FFWCC, 2003).

Maintaining the heterogeneous native plant communities, which are intrinsic to a healthy lake littoral zone, may also facilitate an improvement in fish stocks and wading birds under conditions brought about by the Preferred Alternative. By improving lake hydroperiods, including a lowering of overall lake stages and reductions in both prolonged high and extreme high lake stages, conditions for wading bird foraging, nesting, spawning and feeding habitat for fish should be improved. When low-to-moderate water levels occur in Lake Okeechobee, resulting in dense plants such as bulrush and peppergrass, the biomass and taxonomic diversity of macro-invertebrates is maximal (Warren and Vogel, 1991). Many of these animals, including grass shrimp, amphipods, and a variety of larvae are integral to the diets of largemouth bass, black crappie, redear sunfish, and bluegill sunfish (Havens and Gawlick, 2005). Alternatives A through E will reduce the occurrences of high lake levels as indicated in Table 6-1, which will benefit fish and wildlife resources in Lake Okeechobee.

All of the alternatives will have more occurrences of extreme low lake levels compared to the No Action Alternative as indicated in Table 6-1. The duration of these low lake stage events is critical to the degree of effects. Much emphasis is placed on the low lake stage PM because it is extremely useful for evaluating potential effects on the endangered snail kite, in particular effects on its habitat and food source as discussed in Section 6.3.1. During extreme low lake levels, mobile species such as manatees, alligators, turtles and predator fish could seek refuge in Lake Okeechobee's rim canal, or principle navigation canals.

6.4.2. NORTHERN ESTUARIES

A critical reproduction period for many estuarine dependent organisms is during the period of March–June. The volume, duration and timing of freshwater inflow to estuaries is extremely important for the optimal balance of salinity. Oysters are commonly used as an indicator of spawning season, but many other species of saltwater fish begin spawning in late winter/early spring. Without optimum salinity, because of excessive freshwater, other fish species may be affected too by fresh water releases. It is during the springtime that freshwater flows to the estuaries should be monitored closely and possibly reduced, so larvae are retained in the system and not flushed out by excessive freshwater flows. Freshwater releases should be monitored to allow for appropriate salinity conditions for oyster reproduction. Optimal salinity for spawning is 10-30 ppt (Mazzotti, et al. 2003).

To avoid repeating the estuary effects, please refer back to Section 6.2.2 for environmental effects to northern estuaries.

Caloosahatchee Estuary

Alternatives A through E out-performed the No Action Alternative, having fewer months with mean monthly inflows greater than 2800 cfs (Table 6-6). The Preferred Alternative had seven fewer months, compared to the No Action Alternative, of flows greater than 2800 cfs.

TABLE 6-6: CALOOSAHATCHEE ESTUARY

Mean Monthly Flows: Mar-Jun			
CFS:	<450	450-2800	>2800
No Action	75	46	23
Alt A	43	84	17
Alt B	44	82	18
Alt C	49	78	17
Alt D	56	73	15
Alt E (preferred)	56	72	16

St. Lucie Estuary

During the critical period (March-June) when many estuarine dependent species reproduce, the alternatives all out-performed the No Action Alternative, having fewer months with mean monthly inflows greater than 2000 cfs. The Preferred Alternative tied Alternative B with six less months of flows greater than 2000 cfs (Table 6-7).

TABLE 6-7: ST. LUCIE ESTUARY			
Mean Monthly Flows: Mar-Jun			
Alternative	<350	350-2000	>2000
No Action	60	61	23
Alt A	61	65	18
Alt B	62	65	17
Alt C	62	61	21
Alt D	58	66	20
Alt E	60	67	17

Lake Worth Lagoon

Alternatives A through E either out performed or equaled the No Action Alternative. Analysis of the seven-day moving average revealed only small differences between the alternatives with times exceeding 500 cfs all falling within five or six days of each other Table 6-8. Analysis of the two-day moving average indicated that the Preferred Alternative equaled the No Action Alternative while all other alternatives had fewer exceedances of the 1000 cfs criterion. Results for the alternatives all fell within three to 11 days of each other. Comparing differences (five to six days, three to 11 days) to the number of days in the POR (>13,000) provides perspective on just how small these differences are. The differences between the alternatives were so minimal, that it would be difficult to discern any ecological consequences if one alternative was selected over another.

TABLE 6-8: LAKE WORTH LAGOON			
Moving Average Flow (S40 + S41 + S155)			
Number of days in 36 year POR			
CFS:	7-day < 500	7-day > 500	2-day >1000
No Action	12,717	432	420
Alt A	12,740	409	412
Alt B	12,742	407	409
Alt C	12,736	413	414
Alt D	12,737	412	412
Alt E (preferred)	12,736	413	420

6.4.3. EVERGLADES AGRICULTURAL AREA

Under any of the alternatives, regulatory discharges from Lake Okeechobee would be confined to existing canal systems and flow through the EAA without impacting agricultural fields or remnant wetlands where wildlife may occur. Although canal stages may be slightly higher at certain times of the year, this is not expected to be at any level that may affect existing fish and wildlife habitat.

6.4.4. WATER CONSERVATION AREAS (GREATER EVERGLADES)

Wading Bird Nesting Success: Wading birds nest from January through May in the Everglades. The two performance measures that address wading bird nesting in the WCAs are hydrologic recession rates and reversals. Recession rates are the declines in water depths during the dry season whereas Reversals are increases in water depths during this same period.

Recessions: As water depths decline in the dry season, wading bird food species are concentrated in the shallower water, increasing the wading birds' feeding efficiency. Optimal water depths for wading birds vary by species; the birds move across the landscape to areas of preferred water depths as water levels decline. Concentration of prey as water levels drop allows the parent birds to feed their hatchlings and to successfully fledge the year's young.

Target recession rates are a decrease of -0.1 foot per week ("good is -0.05' to -0.16' per week). Model output reports the average number of weeks that recession rates fall into this "good" category, and the goal is to increase the percent of these preferred weekly recession rates during the wading bird breeding season. Higher numbers are better, so Alt D is preferred.

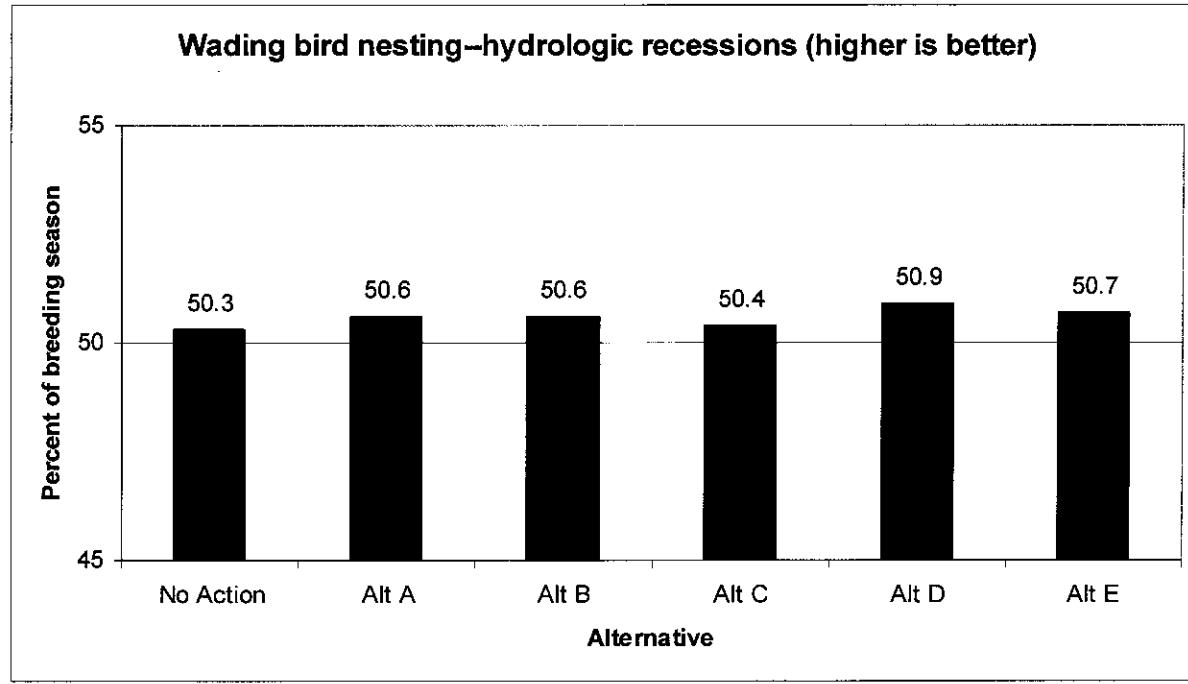


FIGURE 6-3: PERCENT RECESSIONS DURING THE WADING BIRD BREEDING SEASON

Reversals: When water levels rise during the breeding bird season (January through May), food prey that was concentrated in shallower pools disperses, reducing feeding

efficiencies of the parent birds. When parent birds find less food, their nesting success is poorer, so reversals should be avoided during this period of the year. This performance measure averages the percent of weeks of reversals (when recession rates are above -0.04' per week). Lower numbers are better. For this Performance Measure, Alt D is slightly better than the others.

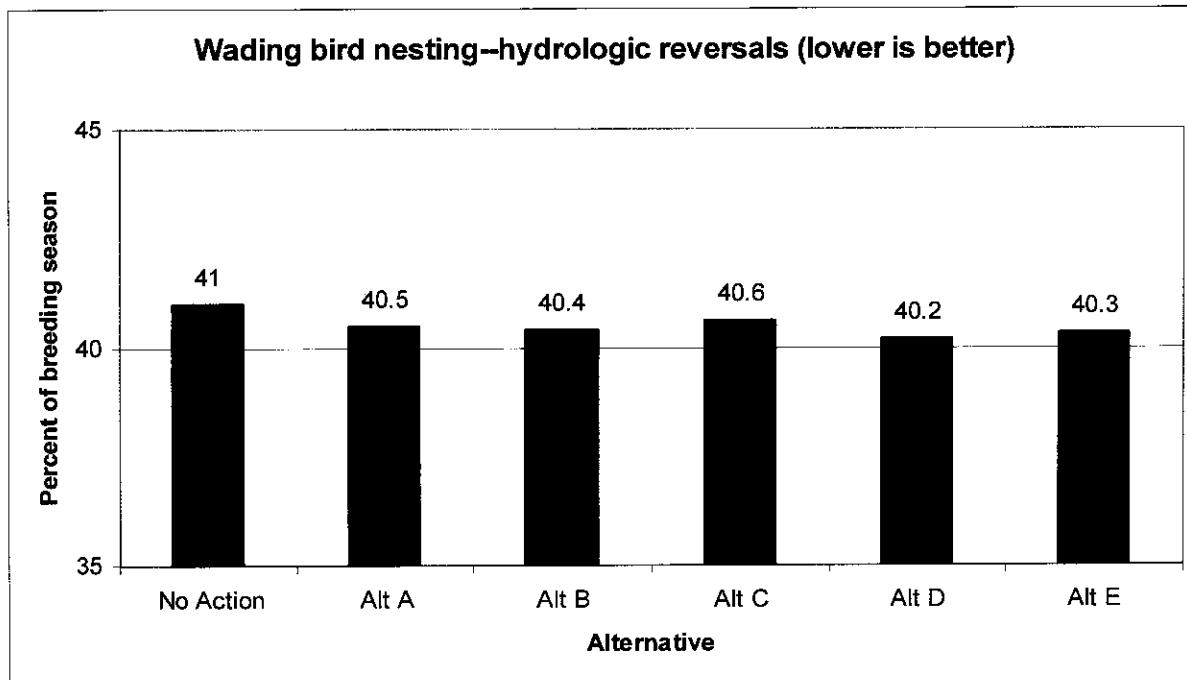


FIGURE 6-4: PERCENT REVERSALS DURING THE WADING BIRD BREEDING SEASON

Greater Everglades Snail Kite: Snail Kites reproduce from approximately February 15 through May 15 each year, and they feed upon Apple Snails. Rapid water level increases during this period drown Apple Snail eggs, and loss of a year's cohort of Apple Snail eggs reduces their populations for two to three years. Snail Kite reproduction and survival, which rely on these snail populations, are also harmed by loss of Apple Snails.

The Performance Measure for the Snail Kites identifies "Optimal" (O) conditions, "Marginal" (M) conditions, and "Unsustainable" (U) habitat conditions for Snail Kites. For the Indicator Regions, changes in ratings were valued as 0 for unchanged, 1 or 2 for improvement (one category or two categories of improvement), and -1 or -2 similarly for declines. These values are summed over the Indicator Regions to indicate Greater Everglades habitat suitability under the alternatives.

For these alternatives, changes in any Indicator Regions (in the Indicator Regions defined in section 4.3.3) were only one class up or down. Therefore, Alts A and B

improved Snail Kite habitat quality, while the other three alternatives did not change conditions overall from the No Action alternative.

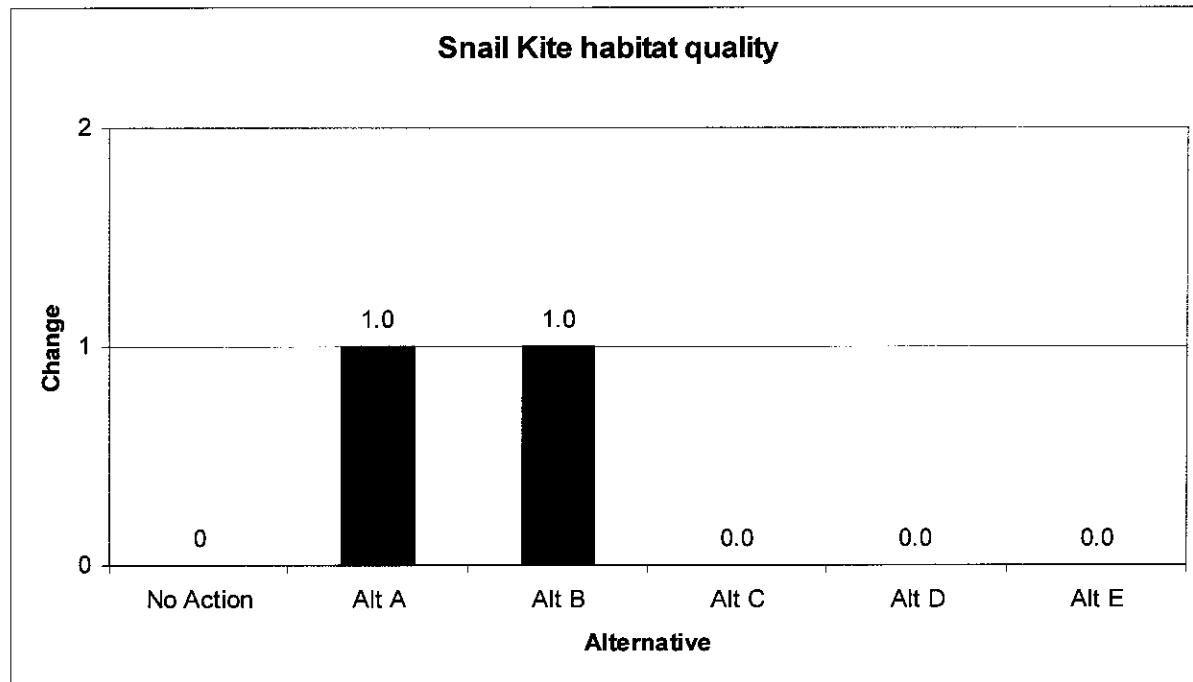


FIGURE 6-5: COMPARISON OF SNAIL KITE HABITAT SUITABILITY

6.5. ESSENTIAL FISH HABITAT ASSESSMENT

6.5.1. PREFERRED ALTERNATIVE

In addition to this section, further evaluation of estuary effects for the Preferred Alternative can be found in Sections 6.2.2 and 6.4.2. A "No Objection" letter dated July 24, 2007 for the Corps' action was received from NMFS and included in Appendix H.

The Preferred Alternative shows improvement to both the Caloosahatchee and St. Lucie estuaries, and the Lake Worth Lagoon. High freshwater flows are equal to or reduced for the Caloosahatchee Estuary and the St. Lucie Estuary, thereby potentially reducing the frequency of algal blooms, turbid water and fish kills. Although improvements are not substantial, improved conditions for sensitive estuarine biota, such as species dependent on this habitat for egg, larval, and juvenile stages, may be seen. The Preferred Alternative will reduce the number of flows >2000 cfs from Lake Okeechobee to the St. Lucie Estuary. This reduction in high regulatory flows may provide improvement for the St. Lucie Estuary. Improved conditions within estuarine communities may result in improvements to SAV, oysters, fish, such as redfish, grouper, snook and spotted seatrout, and other fauna in the estuary.

Springtime is a critical period in estuarine systems because many estuarine dependent organisms reproduce at this time. High flows >2800 cfs in the Caloosahatchee and >2000 cfs in the St. Lucie, may prevent the early life stages of fish, shellfish and other commercially and recreationally important species from utilizing estuarine habitat. Alternatives with the fewest number of mean monthly flows exceeding these limits are to be preferred.

One important operational change from the No Action to the Preferred Alternative is the built in flexibility of the Preferred Alternative to provide relief to the estuaries. This was accomplished through the ability of the Preferred Alternative schedule to make long-term, low volume releases to the estuaries, when the estuaries would benefit from such release. These releases include low-volume pulse releases and base flow releases. The intent of the releases is to maintain desired salinity in the estuaries, and reduce the potential for future prolonged high-volume releases that may be undesirable to EFH such as SAV.

6.5.2. ALTERNATIVES A THROUGH E

Refer to discussions in Section 6.2.2 and 6.4.2.

6.6. HISTORIC PROPERTIES

Historic properties would not be affected by any of the alternatives.

6.7. SOCIO-ECONOMIC

The following discussion of socio-economic existing conditions focuses on the principal social and economic forces of the Lake Okeechobee region. The forces include: commercial navigation via the Okeechobee Waterway, agriculture in the area immediately surrounding Lake Okeechobee, urban municipalities, recreation and sport and commercial fishing. More detailed information on the socio-economic conditions within the study area are presented in Appendix D.

Commercial Navigation

The Lake Okeechobee Waterway connects Stuart on the Atlantic Ocean with Ft. Meyers on the Gulf of Mexico. It includes 154 miles of navigation channel and five lock and dam structures. The Port Mayaca and Moore Haven locks connect Lake Okeechobee to the St. Lucie Canal and Caloosahatchee River respectively. Commercial navigation on this waterway has been stable over the ten year period from 1988-1998, with sustained year to year variation (USACE 1998). The Lake Okeechobee Waterway was used to transport 430,000 tons of freight in 1995. Petroleum products were the predominant commodities transported (USACE 1998). There are no commercial shipping lines that regularly pass through the waterway, rather traffic consists primarily of special barge traffic which takes advantage of the shortcut across the Florida peninsula, saving about three to five days of travel.

Agriculture

The immediate area surrounding Lake Okeechobee is largely rural, with agriculture being critical to the local and regional economy. There are estimated to be over

700,000 irrigated acres of farm land in the LOSA, which includes the EAA. The EAA alone, accounted for over \$750 million in agricultural production, and provided employment for over 20,000 full time workers in 1989 (Snyder and Davidson, 1994). Agricultural production consists predominantly of sugarcane, as well as rice, row crops, and sod. There is also extensive improved and unimproved pastureland, particularly west and north of Lake Okeechobee. The St. Lucie and Caloosahatchee basins, which also receive irrigation water from Lake Okeechobee, contain an estimated 138,000 and 49,000 acres, respectively of citrus crops, sugarcane, vegetables, sod, and ornamentals (USACE 1998). During prolonged droughts, significant volumes of water are required by the agricultural community in the Lower East Coast. Row crops such as truck vegetables, are the predominant crop type in the Lower East Coast.

Urban

The urban landscape surrounding Lake Okeechobee includes the incorporated municipalities of Belle Glade, Clewiston, Moore Haven, Okeechobee City, Pahokee, and South Bay. These communities range in population from approximately 1,635 (Moore Haven) to 14,906 (Belle Glade). Residential and commercial water users depend on Lake Okeechobee's water supply for well field recharge, drinking water, and industrial processes.

In addition to the area immediately surrounding Lake Okeechobee, the populations of the Caloosahatchee and St. Lucie basins, and of the Lower East Coast, can be affected by Lake Okeechobee operations. The 2000 population of the affected 16 county region was approximately 8.5 million. The combined population of these areas, along with the rural areas adjacent to Lake Okeechobee, accounts for just less than 40 percent of the State's population. The economy of south Florida is based on services, agriculture, and tourism. The Lower East Coast counties' economies are strongly oriented to the services industry, while the counties surrounding Lake Okeechobee are heavily agricultural.

Recreation and Sport Fishing

Lake Okeechobee is the largest recreational resource in the region and provides a wide variety of water based recreation including fishing, boating, picnicking, sightseeing, camping, swimming, hunting, airboating, and hiking. The littoral zone, along Lake Okeechobee's western shore, provides valuable habitat for the lake's popular sport fishery. Lake Okeechobee is recognized as supporting one of the best recreational fisheries in the nation. A variety and abundance of sport fish, including largemouth bass, black crappie, bluegill, and redear sunfish are targeted by sport fishermen from around the country. Consequently, sport fishing is a major activity on Lake Okeechobee. There is also several major sport fishing tournaments held on Lake Okeechobee annually, which bring significant revenues to the marinas, fishing guides, hotels, and support industries along the lake. It should be noted that Lake Okeechobee supports several commercial finfishing endeavors, including fisheries for bullhead catfish, gizzard shad, striped mullet (*Mugil cephalus*), and gar (*Lepisosteus spp*).

Heavy seasonal waterfowl utilization of Lake Okeechobee attracts tourists and recreational enthusiasts, such as hunters. Common waterfowl species include ring-necked duck (*Aythya collaris*), American wigeon (*Anas americana*), Northern pintail (*Anas acuta*), green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), lesser scaup (*Aythya affinis*), and Florida duck (*Anas fulvigula*).

Lake Okeechobee has been a historic tourist destination for purely aesthetic reasons. Airboat rides are popular tourist activities on Lake Okeechobee. Recreation levels in 1996 at Lake Okeechobee are estimated at over 64,000 visitor-hours, with an annual value of over \$78,000,000 (USACE 1998).

Commercial Fishing

The commercial fishing industry in Lake Okeechobee utilizes primarily haul seines to catch bluegill, redear sunfish, and catfish. Catfish are caught by trot lines, and wire traps. Bullhead, shad, gar, mullet, and tilapia are also caught, although since the net ban, mullet are no longer considered a commercial species. There are reports of commercial mullet trapping on Lake Okeechobee, mostly in the canals (FFWCC pexs. corn.). The annual wholesale value of the commercial fishery was estimated in 1998 (USACE) to be approximately \$2,326,932, employing about 210 fishermen and landside workers.

There are also commercial fisheries on Lake Okeechobee, which harvest the American alligator and the Florida soft-shell turtle (Diemer and Moler, 1995). Alligators are harvested from the lake population to supplement the stock in alligator tanning operations. Soft-shell turtles are harvested by commercial fishermen, with some individual yields in excess of 13,640 kilograms (30,000 pounds) annually. The majority of the harvest is prepared for shipment to Japan, or sold locally, primarily to the Miccosukee Tribe of Indians of Florida.

Land Use

The following section will address the general land use within the vicinity of Lake Okeechobee. The area is rural in character with most lands dedicated to agriculture. In general, sugar cane is the predominant crop in the south, row crops and sugar cane in the east, and pastureland with dairy production in the north. Urban areas, which are generally few and modest in population, service the agriculture sector, as well as the tourists who come to Lake Okeechobee to fish, hunt, and enjoy other recreational pursuits.

Agriculture

There is an abundance of agricultural lands surrounding Lake Okeechobee and throughout the affected area. The section below discusses the existing agricultural conditions by physiographic region, beginning with the largest area, the EAA, immediately south and east of Lake Okeechobee.

Everglades Agricultural Area

More than 600,000 acres are farmed in Palm Beach County (UFBEBR, 1995), and sugarcane was harvested in about half of that acreage in 1996 (FASS, 1996d). Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value crops, including sugarcane and vegetables. Sugarcane receipts accounted for 68 percent of total field crop sales in Florida in 1996 (FASS, 1996c). The EAA is known for its sugarcane production and sugar processing, but Palm Beach County also ranks 15th among Florida counties for acres of citrus (PASS, 1996b). This region is characterized by mid-size farms averaging 690 acres each with high productivity of more than \$1300 per acre (UFBEBR, 1995). More than 18,000 people are employed in agricultural production and services representing a payroll of more than \$26 million (UFBEBR, 1995). Total market value of agricultural products in Palm Beach County is approximately \$900 million, ranking it first among counties in the State of Florida (UFBEBR, 1995) and third among U.S. counties (FDACS, 1994).

The EAA is highly dependent upon the system of canals running through the region to provide necessary drainage of excess water during the wet season as well as supplemental water supplies for irrigation during the dry season. Approximately two thirds of the land farmed in the EAA is irrigated, totaling more than 400,000 acres (UFBEBR, 1995). The EAA has traditionally relied upon Lake Okeechobee for its water supply during drier periods, and looked to the WCAs to the south to receive their excess drainage.

Continued agricultural production in the EAA has become increasingly controversial. Some of the factors that may affect the EAA agriculture include water quality concerns, soil subsidence, and urban encroachment. The water quality concerns, particularly phosphorus loading, are being addressed through best management practices, STAs, and growing use of organic farming practices and rice cultivation in rotation with sugarcane production. Although sugarcane cultivation in the EAA has come under some sharp criticism in recent years, sugarcane is recognized as the most appropriate crop for this region. Sugarcane requires less phosphorus fertilizer than other crops grown in the EAA (Sanchez, 1990), and sugarcane has been found to remove 1.79 times more phosphorus than was applied as fertilizer (Coale et al., 1993). Florida sugarcane only requires small amounts of pesticides due to disease resistant and tolerant cultivars, and uses cultivation instead of herbicides for weed control. Sugarcane also tolerates greater variability in water table levels, allowing for more flexible water management strategies (Glaz, 1995).

Soil subsidence has become a potential threat to long-term crop production in the EAA. The average historic rate of subsidence of one inch per year has slowed to 0.56 inches per year since 1978 (Shih et al., 1997). The lower rate was attributed to several factors including higher water tables and an increased proportion of land planted to sugarcane. Surveys conducted by Shih et al. (1997) found an average of 1.62 feet to 4.36 feet of soil remaining over 11 transects. Prevention of continued soil subsidence will depend on maintaining high ground water levels to prevent further oxidation of the soil profile. This, in turn, will require development of more water-tolerant sugarcane varieties and/or

increased rice cultivation. This research is currently underway and showing promising results (Glaz, 1997). A strong agricultural economy in the EAA based on profitable crop production is the best defense against conversion of agricultural land to urban land.

Kissimmee River Basin

Immediately north of Lake Okeechobee, Osceola, Polk, Highlands, and Okeechobee counties surround the Kissimmee River Basin. More than two million acres in these counties are farmed, with more than half of this area devoted to pastureland (UFBEBR, 1995). Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value crops, including citrus. Approximately a quarter of a million acres in the Kissimmee River Basin are irrigated (UFBEBR, 1995), requiring a dependable water supply. This region is characterized by large farms with relatively low productivity per acre. These four counties are among the top five counties in Florida for cattle production, both beef and dairy (FASS, 1996a). More than 200,000 acres are used for citrus production. Approximately 11,000 people are employed in agricultural production and services representing a payroll of approximately \$21 million. The market value of all agricultural products in this region totals approximately \$575 million (UFBEBR, 1995).

Martin and St. Lucie Counties (Upper East Coast)

At present, the dominant land use in the basin is agriculture (covering approximately 45 percent of the basin). Agricultural activities include 228,000 acres of citrus, 211,000 acres in range and citrus, and 9,500 acres of vegetable crops (SCS, 1994). The present urban land use (17 percent of the basin) is concentrated along the coast and the lagoon shorelines. Urban growth is rapidly extending westward, replacing agricultural land. Future land use patterns indicate that this trend will continue as urbanization intensifies along the coast, especially in the southern counties (Swain and Bolohassen, 1987). Present forested uplands and wetlands comprise 11 and 18.8 percent of the basin, respectively.

Caloosahatchee River Basin

Approximately one half million acres are farmed in the Caloosahatchee River Basin, and approximately three-fourths of that area is pastureland. The region is characterized by large farms averaging 1,800 acres, with relatively low productivity per acre (UFBEBR, 1995). Glades County ranks eighth in the State of Florida for cattle production (FASS, 1996a). Citrus production in the Caloosahatchee River Basin covers more than 20,000 acres (FASS, 1996b) and is currently increasing. Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value citrus crops. Approximately 5,000 people are employed in agricultural production and services, and the payroll totals approximately \$5 million. Agricultural products in this region have a total market value of more than \$135 million (UFBEBR, 1995).

More than 77,000 acres of farmland are irrigated in the Caloosahatchee River Basin (UFBEBR, 1995). Reliable water supply is a big concern in this region which has traditionally relied upon water deliveries through the Caloosahatchee River from Lake

Okeechobee. Irrigation demands can be expected to increase as additional land is used for citrus production.

Urban Land Use

A significant use of land outside the agricultural context is for urban development. Five incorporated communities are situated around Lake Okeechobee and range in population from approximately 1,600 to 15,000.

**TABLE 6-9: 2000 POPULATION ESTIMATES, COMMUNITIES SURROUNDING LAKE OKEECHOBEE
(2000 CENSUS)**

COMMUNITY	POPULATION	COUNTY
Belle Glade	14,906	Palm Beach
Clewiston	6,460	Hendry
Moore Haven	1,635	Glades
Okeechobee City	5,784	Okeechobee
Pahokee	5,985	Palm Beach

The Brighton Seminole Indian Reservation occupies a large area of land west of Lake Okeechobee in Glades County. The southern end of this reservation is near the HHD just north of Lakeport. Major transportation corridors around the perimeter of Lake Okeechobee include several highways and railroads. County Road (CR) 78 parallels Lake Okeechobee along its western and northern shores from Moore Haven to Okeechobee.

From Lake Okeechobee, State Highway 98 follows the northern and eastern portion of the lake to Pahokee. CR 715 then follows the HHD from Pahokee to Belle Glade, where State Highway 27 follows the southern lake area back to Moore Haven and CR 78.

The municipalities of Stuart at the mouth of the St. Lucie Estuary, Fort Pierce to the north of Stuart, and Jupiter to the south, are the three principal urban centers nearest the outlet of the C-44 within Martin and St. Lucie Counties.

On the west side of Lake Okeechobee, along the Caloosahatchee River and on Charlotte Harbor, urban areas include the cities of LaBelle, Alva, Olga, Fort Myers, and Cape Coral. Land use adjacent to the Caloosahatchee Estuary is largely residential and urban with the city of Cape Coral on its northern bank and the highly urbanized City of Fort Myers on its south bank. Both of these communities have experienced rapid growth with even more growth anticipated in the near future (SFWMD, 1997).

Recreation Resources

Recreation resources in the Lake Okeechobee region are primarily water based within Lake Okeechobee and include boating, fishing, and nature interpretation. Lake Okeechobee provides approximately 40 miles of navigable waterway for commercial

navigation and many more for recreational boating. Twenty-five Corps-built land and water-based recreational facilities are located along Lake Okeechobee. The Florida National Scenic Trail encompasses Lake Okeechobee atop the HHD (approximately 140 miles long). Approximately 94 percent of the recreation lands available to the public in this region are owned by the State or Federal government (SCOW, 1994). Bike riding, hiking, picnicking, camping, and nature interpretation are popular land based recreation activities in the region. Substantially altered water deliveries to this region could result in flooding and have a detrimental affect on many natural and recreation resources in the area. The ample water based recreation resources in the Lake Okeechobee region receive extensive use and future demand is anticipated to increase. The St. Lucie Canal provides approximately 34 miles of navigable waterway with four Corps/County recreation facilities that include boating, fishing, camping and day use facilities (USACE, 1991). The approximately 44 miles of Intracoastal Waterway, within the Upper East Coast, provides many coastal recreational navigation opportunities.

Public beaches in the Upper East Coast are the most popular forms of recreation in the region. Four State of Florida Aquatic Preserves, and four State Parks and Recreation Areas are within the Upper East Coast. Five artificial coastal reefs provide popular diving and fishing spots. The region also includes high quality recreation opportunities within the Dupuis Reserve State Forest and Wildlife and Environmental Area and the St. Lucie Inlet Preserve. Overall, existing recreation resources in the region receive heavy annual usage that is expected to increase in the future.

Recreation resources in the WCA region are inland water and upland resources that include the Arthur R. Marshall Loxahatchee National Wildlife Refuge, and Rotenberger and Holey Land WMAs (SCOW, 2000). These areas provide high quality boating, fishing, and nature interpretation activities. The Miccosukee State Indian Reservation is within the WCA region boundary. Hunting, boating, and fishing occur within the Everglades WMA, including the Miccosukee State Indian Reservation.

The Caloosahatchee River provides approximately 67 miles of navigable waterway with ten Corps recreation facilities that include boating, fishing, picnicking, and camping. The J.N. "Ding" Darling National Wildlife Refuge, a popular birding area, administers Caloosahatchee, Matlacha Pass, Island Bay National Wilderness area and Pine Island National Wildlife Refuge, all located near the region's western edge. Boca Grande Pass is world renowned for record tarpon, and Sanibel and Captiva Islands are reported among the top shelling destinations in the Western Hemisphere.

Caloosahatchee State Park and Recreation Area is located near Alva on the Caloosahatchee River. Estero River and Hickory Creek State Canoe Trails are within the region and provide excellent recreation resources. Cayo Costa State Park, Sanibel Island State Park, and State Aquatic Preserves are located in the region.

6.8. AESTHETICS

Aesthetics within the study area should not be affected in the short-term. Since there will not be any structural modifications to the existing operations system, no visible impediments to existing landscapes will be present. While plant communities may change over time through varying water management practices, succession, and competition, among other factors, significant (observable) changes to plant communities usually require a few to several years to occur. Over the longer term, improved hydroperiods within Lake Okeechobee and the St. Lucie Estuary are expected to benefit native plant communities which should support enhanced numbers of native fish and wildlife. A reduction in the occurrence of prolonged and extreme high lake stages within Lake Okeechobee for instance should reduce excessive turbidity, and enhance wading and foraging conditions and nesting success for wading birds, two components of the ecosystem which contribute greatly to the visual aesthetic/appeal. Healthier seagrass beds in the St. Lucie Estuary and Indian River Lagoon will provide better habitat for fish stocks which, although not easily seen by the casual observer, also act as food sources and support bald eagles and other fish eating raptors whose presence may enhance the wilderness aesthetic of the estuary.

There are not expected to be any affects on existing or future aesthetics within the EAA, nor to the Caloosahatchee River. Neither area benefits greatly from the proposed action in terms of improved hydroperiods and flows through these areas will not affect related resources, existing land use or other variables that may enhance or detract from current appearances.

6.9. RECREATION

Improvements to Lake Okeechobee's hydroperiod should reduce the occurrence of prolonged high lake stage events in particular, that have adversely impacted native aquatic and marsh vegetation around the lake over the past several years. The littoral and marsh habitat provides important nesting, breeding and feeding areas for fish and wildlife and the health and sustainability of these vegetation communities is crucial to the recreation resources, particularly fishing, hunting, and wildlife viewing. The Preferred Alternative (1bS2-m), by allowing for lower lake levels, would protect and enhance fish and wildlife habitat within Lake Okeechobee, to a certain degree, by reducing over inundation of emergent and floating vegetation and improving light penetration to SAV, components of which are important habitat throughout the life cycle of fishes, wading birds, raptors, waterfowl, and other animals which make up the food chain. Moreover, lower lake levels may also contribute to a reduction in sediment and nutrient transport into the back water marsh areas and littoral zone and reduce resuspension of nutrients which contribute to algae bloom production. These improvements to hydroperiod, aquatic vegetation, and water quality should translate into better opportunities for fish and wildlife reproduction, foraging and cover, and allow for larger, more sustainable populations for fishing, hunting, and wildlife observation.

The slightly reduced freshwater flows >2000 cfs to the St. Lucie Estuary in particular may improve fish and wildlife habitat and improve conditions for the fishery. Although high regulatory releases would still be necessary on occasion, the reduced volume of

lake water sent to the estuary would improve overall salinity regimes, water clarity and color, reduce turbidity and probably reduce the oxygen demand of deposited silts. Any condition that favors growth and expansion of seagrasses and improved water quality, will enhance the fishery and opportunities for commercial and sport fishing. Wildlife viewing may also be enhanced with healthy and sustainable seagrass beds. Habitat for prey species such as invertebrates and forage fishes which are food sources for eagles, wading birds, marine mammals and other watchable species will enhance opportunities to view these animals. Manatees, which feed directly on seagrasses will also benefit through improved conditions for their primary food source

All of the proposed alternatives, including the Preferred Alternative, would have more occurrences of low water stages, and extreme low water stages, than the WSE schedule. Low water events would impact recreational boat users navigating Lake Okeechobee, and accessing the lake from local boat ramps. Some boat ramps and marinas may be inaccessible during low water events below >11 feet.

6.10. NAVIGATION

Boating access to Lake Okeechobee is affected by water levels. At lake stages below 12.56 ft., NGVD, the authorized project depth cannot be maintained. During low lake level, navigational access to much of the fishing area is reduced. The rim canal and boat trails become inaccessible during low water periods. Boat ramp access and marina access is impacted in certain areas around Lake Okeechobee when water levels fall below 12 feet. Table 6-10 below gives lake conditions at a glance for Route 1.

**TABLE 6-10: NAVIGATION DEPTHS ON LAKE OKEECHOBEE, ROUTE 1
(SOURCE: WWW.SAJ.USACE.ARMY.MIL)**

Lake Level (ft., NGVD)	Available Navigation Depth (ft.)
13.12	7.06
12.62	6.56
12.12	6.06

The hydrologic PM used for navigation was based on the 1965-2000 simulation POR. The performance of each alternative was measured by the number of times in the POR that lake stage is below 12.56 feet (Table 6-11). In summary, all of the alternatives performed worse than the No Action Alternative for days below 12.56 feet. Adverse effects to navigation would occur under any alternative, including the Preferred Alternative.

TABLE 6-11: DAYS BELOW 12.56 FT.

Alternative	Days lake stage below 12.56 ft., NGVD
No Action	2876
A	4839
B	4922
C	4909
D	5156
E (preferred)	5128

6.11. COASTAL BARRIER RESOURCES

There are no coastal barrier resources located in the project area.

6.12. WATER SUPPLY

Several PMs were used to evaluate impacts to water supply as indicated in Table 6-12. In addition to providing the PMs, a weighting scoring system was used to give an overall assessment of water supply performance for each of the runs evaluated. The chief use of the scoring system was to allow an overall ranking of each alternative from a water supply standpoint as part of the process of considering the relative performance of each alternative across goal areas.

The scores were assigned on a scale of +3 to -3 with +3 being much better, +2 being better, +1 being slightly better and 0 being no change. Similarly -1 is slightly worse, -2 is worse and -3 is much worse. All measures were assigned the same weight except that the number of water years with cutbacks greater than 100,000 acre feet was weighted 0.5 while the number greater than 200,000 was weighted as 1.5. All other measures are weighted as 1.

All scores are relative to the No Action condition. For the Recover based measures performance targets have been established and the scoring considered the performance of the No Action Alternative relative to the target in developing the scores. For the other measures the absolute magnitude of the score in the No Action condition and the relative change in the frequency or amount relative to that No Action Alternative was used.

All alternatives evaluated performed better than the No Action Alternative. Alternatives A, B and C performed about equally and were in the better range, while Alternative D performed only slightly better than the No Action.

The performance of the Alternative E (Preferred Alternative) is virtually identical to Alternative D, and slightly better than the No Action Alternative.

12/5/2006

Lake Okeechobee Regulation Schedule Study - Water Supply Evaluation

Weight	Water Supply (data from Website Analysis 11/21/06)	No Action		Alternative A		Alternative B		Alternative C		Alternative D		Alternative E	
		Data	Dif from Base	Data	Dif from Base	Data	Dif from Base	Data	Dif from Base	Data	Dif from Base	Data	Dif from Base
1	Additional Supply Side Management (SSM) Cutbacks (acre-feet)	0	-385,600	2	-358,020	2	-368,080	2	-274,790	2	-279,650	1	-279,650
2	Frequency of Water Shortages (years)	7	4	57%	2	4	57%	2	7	100%	0	7	100%
2	Duration of Water Shortages (months)	17	9	53%	2	10	59%	2	13	76%	1	13	76%
2	Severity of Water Shortages Score	11	5	45%	2	5	45%	2	8	73%	1	8	73%
0.5	Water Years with SSM Cutbacks >100,000 acre-feet	4	0	0%	2	1	25%	2	0%	2	1	25%	2
1.5	Water Years with SSM Cutbacks >200,000 acre-feet	1	0	0	0	0	0	1	0	0	0	0	0
1	EAA Percent of Demands not Met	6	5	83%	1	6	100%	0	5	83%	1	6	100%
1	Other LOSA Percent of Demands not Met	4	3	75%	1	3	75%	1	3	75%	1	3	75%
2	Coastal Basin Supply Side Management Water Shortages	5	4	80%	1	0	0%	1	4	80%	1	5	100%
13	Overall Score ---->	0.00	1.46	1.38	1.46	1.38	1.46	1.46	0.54	0.54	0.54	0.54	0.54
Scale System:													
(3) = Much Better													
(2) = Better													
(1) = Slightly Better													
(0) = No Difference													
(-1) = Slightly Worse													
(-2) = Worse													
(-3) = Much Worse													

TABLE 6-12: WATER SUPPLY EVALUATION

6.12.1. EVALUATION OF SFWMD WATER SHORTAGE CUTBACK ASSUMPTIONS

This section presents a summary comparison of water supply performance from South Florida Water Management Model simulations of the No Action Alternative, the Preferred Alternative with SFWMD's previously proposed LOWSM and the Preferred Alternative with Existing Water Shortage Triggers (WST). As discussed in Section 4.4, this comparison was conducted because until recently, there had been no final agency action by SFWMD concerning its water shortage rule. In order to address the range of potential cumulative impacts of LORS with action on water supply rules pending by SFWMD, the Corps conducted this comparative analysis. SFWMD had proposed a 2006 draft LOWSM Plan which was later determined to be inconsistent with SFWMD rules pertaining to Lake Okeechobee MFLs. SFWMD conducted additional analysis and its final published rule does not change the existing WST. Prior to proposing this rule, SFWMD conducted several simulations attempting to improve performance of low stages in the lake by modifying some of the elements of LOWSM. These simulations provided enough evidence to demonstrate that irrespective of which Lake Okeechobee Water Shortage Management scheme is used, no major improvements in the Lake Okeechobee MFL performance are achieved.

Table 6-13 shows that for the individual measures and for the overall score the Preferred Alternative with LOWSM performs slightly better than the No Action Alternative while the Preferred Alternative with Existing WST performs significantly worse. This is further illustrated by looking more closely at the amounts and percents of demands not met.

TABLE 6-13: SUMMARY COMPARISON OF WATER SUPPLY PERFORMANCE

Weight	Water Supply Performance Measure/Indicator	No Action		Preferred Alt w/LOWSM		Preferred Alt w/ WST		
		Data		Data	Ratio to Base	Rating	Data	Ratio to Base
1	Additional Supply Side Management (SSM) Cutbacks (acre-feet)	0		-279,650	100%	1	1,299,470	-3
2	Frequency of Water Shortages (years)	7		7	100%	0	14	200%
2	Duration of Water Shortages (months)	17		13	76%	1	37	218%
2	Severity of Water Shortages Score	11		8	73%	1	22	200%
0.5	Water Years with SSM Cutbacks >100,000 acre-feet	4		1	25%	2	7	175%
1.5	Water Years with SSM Cutbacks >200,000 acre-feet	1		0		0	4	400%
1	EAA Percent of Demands not Met	6		6	100%	0	15	250%
1	Other LOSA Percent of Demands not Met	4		3	75%	1	10	250%
2	Coastal Basin Supply Side Management Water Shortages	5		5	100%	0	6	120%
13	Overall Score ---->		0.00			0.54		-2.65
Scale System:								
(3) = Much Better								
(2) = Better								
(1) = Slightly Better								
(0) = No Difference								
(-1) = Slightly Worse								
(-2) = Worse								
(-3) = Much Worse								

In addition to the information presented in Table 6-13, simulated water supply performance is discussed based on the SFWMM PM for mean annual supplemental irrigation, demands and demands not met. In the EAA the mean annual volume of demands not met during the 1965-2000 POR are 21,000 acre-feet for the No Action Alternative and the same for the Preferred Alternative with LOWSM (6% not met). The model run for the Preferred Alternative with existing WST, demands not met increase to 55,000 acre-feet and the percentage of demands not met is 15%. In the rest of LOSA the demands not met average 9,000 acre feet (4%) for the No Action Alternative and 8,000 acre-feet (3%) for the Preferred Alternative with LOWSM. For the Preferred Alternative with existing WST the mean annual demands not met are 23,000 acre-feet (10%).

Particular emphasis is given to water supply impacts under the most significant drought conditions experienced within the simulation POR, as water supply needs under drought conditions are highly susceptible to the observed lowering of Lake Okeechobee stages under the alternatives. To do this the mean annual demands not met during the drought years 1971, 1975, 1981, 1985 and 1989 are analyzed. In the EAA the mean annual volume of demands not met during the selected drought years are 61,000 acre-feet (13%) for the No Action Alternative and 58,000 acre-feet for the Preferred Alternative with LOWSM (also 13% not met). The model run for the Preferred Alternative with existing WST for these drought years, shows demands not met increasing to 167,000 acre-feet and the percentage of demands not met is 33%. In the rest of LOSA the demands not met during the selected drought years average 26,000 acre feet (8%) for the No Action Alternative and 21,000 acre-feet (6%) for the Preferred Alternative with LOWSM. For the Preferred Alternative with existing WST the mean annual demands not met are 58,000 acre-feet (17% not met).

In the Lower East Coast Coastal Basins the No Action Alternative and the Preferred Alternative with LOWSM both show five years during which water shortages would be implemented because of low levels in Lake Okeechobee relatively early in the dry season. In the Preferred Alternative with existing WST this increases to six years which is a slight increase. Some of the impacts could be lessened because there may also be locally caused water shortages during those years and the particular months within them when the low levels in Lake Okeechobee indicate that coastal water shortage cutbacks would be implemented.

Water demands not met for the Big Cypress and Brighton Seminole Reservations also increase in the Preferred Alternative with existing WST. These effects are discussed based on mean annual supplemental irrigation demands not met. For the Big Cypress Reservation the mean annual percent of demands not met during the 1965-2000 POR are 4.6% for the No Action Alternative and 7.6% for the Preferred Alternative with LOWSM. The model run for the Preferred Alternative with existing WST shows 9.3% of the demands not being met. For the Brighton Reservation the demands on average 3.5% of demands are not met for the No Action Alternative and 2.4% are not met for the Preferred Alternative with LOWSM. For the Preferred Alternative with existing WST the mean annual percentage of demands not met increases to 9.0%.

Water Supply for the Seminole Tribe of Florida Reservations

Two reservations of the Seminole Tribe of Florida rely on Lake Okeechobee as a secondary supplemental irrigation supply source for their surface water federal entitlement rights, with specific volumes of water identified for this purpose for the Big Cypress Seminole reservation, and an operational plan addressing water shortage declarations for the Brighton Seminole Indian Reservation in the Indian Prairie Canal basin.

The Seminole Tribe has raised concerns about the reliability of Lake Okeechobee as a source under the pending LORS change. Securing a dependable source of water for the Tribe's reservation is of particular important considering the Tribe's surface water federal entitlement rights.

For the Brighton Reservation, other options of securing both short and long-term water supply deliveries to agricultural operations in the Southern Indian Prairie Basin are being evaluated extensively. For the Big Cypress Reservation, forward pumps to deliver water from the lake at lower stages to the Miami Canal will be an important consideration (SFWMD 2007).

Refer to Section 6.19 (Native Americans) for LORSS alternative discussion of effects.

SFWMD LOWSM Efforts Concurrent with the LORSS Final SEIS Preparation

As documented in section 4.4, the SFWMD suspended rule making on the refined LOWSM plan in May 2007 and informed the USACE that the SFWMD may not be able to revise the LOWSM trigger line below the current SSM trigger. In May 2007, the USACE was preparing to release the LORSS revised draft (June 2007) SEIS for public review and comment. In response to the SFWMD's suspension of the LOWSM rule making process, the USACE conducted modeling analysis to quantify the potential effect on water supply performance if no change to the existing SSM trigger line was made. The range of potential water supply performance between the existing SSM trigger line and the SFWMD's refined LOWSM plan was bracketed and included in USACE water supply performance evaluation in the LORSS revised draft (June 2007) SEIS.

Coincident with the release of the LORSS revised draft (June 2007) SEIS, the LOSA was being subjected to water shortage restrictions as the stage of the Lake fell within the Zone A water shortage area as described in SFWMD Rule (40E-22, 40E-21 F.A.C.). Working with the Governing Board and stakeholders, the SFWMD imposed water shortage cutbacks consistent with the 2001 water shortage rule but based on crop demands as they occur during a 1 in 10 level drought (as opposed to average rainfall assumed conditions) and consistent with the SFWMD's MFL criteria. The SFWMD held its last scheduled rule workshop in late summer, 2007. This workshop introduced a rule concept which reflected management of the Lake during the 2007 drought and was consistent with the 2001 version of the rule and the Lake's MFL criteria. The water

shortage rule imposes more significant water restrictions earlier on through LOSA (compared to the existing water shortage management plan established in 2001). This proposal was supported by stakeholders and was presented to the SFWMD Governing Board for authority to publish the rule and adopt the rule, if no public hearing was requested. Because no hearing was requested by October 19, 2007 the rule is expected to be effective November 15, 2007. SFWMD's Notice of Proposed Rule for Lake Okeechobee Water Shortage is provided as Attachment 2 of Appendix G.

Though operational details for implementation have not been finalized by the SFWMD and provided to the USACE in time for publication in the LORS Final SEIS, the water shortage rule is expected to provide water supply performance within the bracketed range that was evaluated in the LORSS revised draft (June 2007) SEIS, as described in section 6.12.1. Water supply performance is expected to fall closer to the evaluation provided for the existing water shortage rules than to the performance with the refined LOWSM. The Water Control Plan will be finalized with effects within the bracketed range for water supply performance documented in this SEIS. Changes to the Water Control Plan to reflect any modifications by the SFWMD to its water shortage management rules can be accommodated under this analysis so long as the SFWMD can demonstrate they do not result in impacts outside the bracketed performance range.

Economic Effects with Potential Supply Side Management

The potential effects of the 2007 draft SEIS LORSS Alternatives, including potential changes in supply side management are summarized in Table 6-14 through 6-17. To account for the uncertainty with SFWMD water shortage cutback rules (discussion is provided in section 2.3 and section 4.4), the potential economic effects with the 2007 draft SEIS LORSS preferred alternative (Alternative E in this main report, which is also referred to as Alternative T3 in the SEIS appendices) are summarized for two potential water shortage management scenarios: (1) the Preferred Alternative with 2006 draft LOWSM water shortage trigger assumptions (the LOWSM assumption is included for all other alternatives, except the No Action Alternative), and (2) the Preferred Alternative with the existing WST assumptions.

Table 6-14 compares value of unmet water demand for agriculture. Impacts will occur to sugarcane specifically, and will not impact other crops. Additionally, all impacts occur in the EAA and none in the four service areas. The dollar totals in table 6-14 represent reduction in sugarcane yields as a result of changes in water supply compared to the No Action Alternative (2007LORS). With the potential supply side management, sugarcane yields in the EAA will be negatively impacted by approximately \$500,000 annually.

The hydrologic effects of the alternative regulation schedules also have implications for M&I water supply. In the LORSS area, most of the M&I water use is in the three service areas of the Lower East Coast. If water demands exceed supplies, shortages may result, and cutbacks may be imposed by the SFWMD. Table 6-15 represents the

effects of the alternative schedules, including potential supply side management impacts.

Tables 6-16 and 6-17 examine the potential effects of the alternative regulation schedules on the RED account. The RED account registers indirect and secondary effects to the region that are expected to result from the direct economic effects of the alternative plans. Direct economic effects represent the impacts of economic stimuli in terms of changes in regional industrial output, earnings, or employment. Indirect economic impacts represent the resultant economic changes in the industries that support and rely upon the industries directly affected by the stimuli. In addition, induced economic impacts are those impacts experienced by all local industries as direct and indirect effects alter household income and ultimately change local household spending patterns. Tables 6-16 and 6-17 display total impacts to the regional economy, a summation of direct, indirect, and induced impacts. A regional input-output model, *IMPLAN*, was used to estimate the RED effects of the LORSS alternatives. This model is defined in Appendix D, section 8-1.

**TABLE 6-14: VALUE OF UNMET DEMAND FOR AGRICULTURAL WATER SUPPLY
EAA AND LEC WITH POTENTIAL SUPPLY SIDE MANAGEMENT (\$2006)***

Scenario	Area	Total 2000	Average Annual 2000
2007LORS	Total	\$2,573,060	\$71,474
1bs2_a	Total	\$3,690,324	\$102,509
1bs2_m	Total	\$3,815,519	\$105,987
T1	Total	\$3,714,756	\$103,188
T2	Total	\$5,323,139	\$147,887
T3 (LOWSM)	Total	\$5,165,974	\$143,499
T3 (WST)	Total	\$20,389,626	\$566,378

**(totals were generated by the South Florida Water Management Model economic post processor, normalized to 2006 prices, and then given an average annual value between the model analysis period of 36 years)*

TABLE 6-15: VALUE OF UNMET DEMAND FOR M&I WATER SUPPLY (2000) WITH POTENTIAL SUPPLY SIDE MANAGEMENT(\$2006)*

Scenario	Area	Total M&I 2000	Average Annual M&I 2000
2007LORS	Total	\$487,630,000	\$10,764,528
1bs2_a	Total	\$(40,894,000)	\$(1,135,944)
1bs2_m	Total	\$(40,894,000)	\$(1,135,944)
T1	Total	\$(40,894,000)	\$(1,135,944)
T2	Total	\$7,997,000	\$222,139
T3(LOWSM)	Total	\$7,997,000	\$222,139
T3 (WST)	Total	\$84,731,000	\$2,353,645

**(totals were generated by the South Florida Water Management Model economic post processor, indexed to 2006 prices, and then given an average annual value between the model analysis period of 36 years. Totals in parenthesis denote that demand has been met and exceeded by the expressed total)*

TABLE 6-16: IMPACTS ON EMPLOYEE COMPENSATION AS A RESULT OF ALTERNATIVE MODEL RUNS, INCLUDING POTENTIAL SUPPLY SIDE MANAGEMENT (2003 DOLLARS)

ALTERNATIVE	IMPACT
2007LORS	\$-10,708
1BS2_a	\$-15,358
1BS2_m	\$-15,879
T1	\$-15,462
T2	\$-22,157
T3 (LOWSM)	\$-21,500
T3 (SSM)	\$-84,009

TABLE 6-17: IMPACTS ON REGIONAL INDUSTRY OUTPUT AS A RESULT OF ALTERNATIVE MODEL RUNS, INCLUDING POTENTIAL SUPPLY SIDE MANAGEMENT (2003 DOLLARS)

ALTERNATIVE	Total
2007LORS	\$-56,309
1BS2_a	\$-80,759
1BS2_m	\$-83,499
T1	\$-81,294
T2	\$-116,510
T3 (LOWSM)	\$-113,053
T3 (SSM)	\$-441,749

6.13. FLOOD PROTECTION

The LORS, along with the levees around the lake, is a method of flood control used as a means to protect life and property adjacent to Lake Okeechobee (USACE, 2000). The top zone of the current regulation schedule describes maximum, safe discharge of floodwater from Lake Okeechobee. It is of the utmost importance that the lake level be reduced as rapidly as possible in this zone to make room for the next possible flood event, to relieve stress and erosion of the levees, and to reduce impact on Lake Okeechobee's littoral zone (USACE, 2000).

A major concern with the present water regulation schedule, and a focus of the LORSS, is regarding the structural stability of the HHD during high water stages. Issues such as seepage, piping, and boils are exacerbated when the lake elevation approaches 18.5 ft., NGVD (USACE, 2005), which is the maximum release elevation of the current schedule. The heightened concern with HHD was emphasized after several hurricanes passed through south Florida during 2004 and 2005, and the significant amount of rainfall that pushed lake elevations to levels that caused HHD issue.

For the current LORSS, a main objective was to look at ways to develop an alternative schedule that lowers the maximum release trigger for flood protection purposes. As such, a PM for flood protection was developed. The PM was selected to formulate releases that minimized lake elevation >17.25 ft. NGVD. Operationally, this means that at elevation 17.25 feet, maximum lake releases would be made east, west and south, in an attempt to lower the high lake levels. The reason for selecting elevation 17.25 feet as the PM elevation was to address the numerous factors that generate uncertainty in the rate of rise on Lake Okeechobee primarily during the rainy season. This elevation would be used as a predictive buffer against Lake Okeechobee rising to an unacceptable high elevation that compromised the integrity of the HHD that could result in a breach of the levee.

The Preferred Alternative, as modeled, significantly reduced lake stages >17.25 ft. The No Action Alternative had 348 days >17.27 ft., whereas the Preferred Alternative had only eight days >17.25 ft. Compared to the No Action Alternative, all alternatives

significantly reduced lake high stages >17.25 ft. Alternative A had nine days above, Alternatives B and C had zero days above, and Alternative D had 12 days above.

Although this section focuses more on flood protection as it relates to the HHD, modeling results showed that the Preferred Alternative would not increase the risk of flooding in other parts of the C&SF system.

6.14. WATER QUALITY

Excessive loads of nutrients to the lake, such as phosphorus, originate from agricultural and urban activities that dominate the watershed. Even though water quality is critical to the health of Lake Okeechobee, the estuaries and greater Everglades, a water quality assessment is outside the bounds of the LORSS. The LORS is operational in nature, and minimal improvements to water quality can be achieved by operational changes. Indirect effects to water quality may be gained through a lower schedule as presented in the Preferred Alternative. The lower schedule may be beneficial to plant growth, which would assist in providing water quality improvements. Reducing the frequency of high volume flows to the estuaries may indirectly improve water quality in those estuaries. Additionally, there are very minor adverse effects from any alternative to the receiving marsh areas in the WCAs. This is primarily due to the STAs water quality treatment capacity (currently 64,000 acre-feet annual average), based on a lake water phosphorus level) constraint on regulatory discharges from Lake Okeechobee to the WCAs. As phosphorus levels decline in Lake Okeechobee more water can be treated in these STAs and delivered south to the WCAs.

Numerous projects, initiatives and programs have been instituted with the express purpose of addressing environmental problems associated with water quality in Lake Okeechobee, Caloosahatchee Estuary and St. Lucie Estuary, as well as the Everglades. A major CERP project that is specifically focusing on nutrient reduction to Lake Okeechobee is the Lake Okeechobee Watershed Project (LOW). As part of the LOW Project, STAs would be constructed to capture nutrients, such as phosphorus, before entering into Lake Okeechobee. Similar projects are being developed along the Caloosahatchee River and St. Lucie Canal. Cumulatively, these actions would assist in improving water quality in Lake Okeechobee and other water bodies within the study area.

TP loading to Lake Okeechobee now averages 714 metric tons per year (mt/yr) averaged over 2002-2006 (SFWMD, 2007). This loading is more than five times higher than the TMDL of 140 mt/yr considered necessary to achieve the target in-lake TP goal of 40 parts per billion (SFWMD, 2007). Due to the operational nature of the Preferred Alternative, it is not anticipated that adverse effects on TMDL goals would occur. On the contrary, if the littoral zone vegetation rebounds from damages experienced from the 2004 and 2005 hurricane seasons, the vegetation may actually assist in the attainment of TMDL goals set by FDEP. No measurable impact to Lake Okeechobee water quality is anticipated from the Preferred Alternative due to the limitations of operational only regulation schedule adjustments.

6.15. HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

A preliminary assessment indicated no evidence of HTRW affecting this action.

6.16. AIR QUALITY

Air quality would not be impacted by any of the alternatives.

6.17. NOISE

With implementation of any of the alternatives, there would be no affect on existing or future noise levels.

6.18. PUBLIC SAFETY

Public health and safety, as it relates to flood protection, was a major factor in the development of alternative regulation schedules. Minimizing the frequency of exceedence of 17.25 feet elevation was used as it offers additional protection for public safety. The detailed evaluation for flood protection is located in Section 6.13.

Not only does public safety relate to flood protection, but it also relates to other objectives of the Lake Okeechobee Water Control Plan such as water supply. The surface and groundwater in the Lake Okeechobee area provide a valuable source of water for public, domestic, industrial and agricultural use for much of southwest Florida. The Preferred Alternative would have minimal impact on current public water supply, as further detailed in Section 6.12.

6.19. NATIVE AMERICANS

There are two federally recognized Indian tribes in Florida today, the Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida. Presently, the **Miccosukee Tribe** has three reservation areas in the State of Florida, Tamiami Trail Reservation, Alligator Alley Reservation and Krome Avenue Reservation. Tamiami Trail Reserved Area, consisting of four parcels of land, is located forty miles west of Miami, is presently the site of most Tribal operations and is the center of the Miccosukee Indian population. The Miccosukee Tribe also has a perpetual lease from the State of Florida for nearly 190,000 acres in WCA 3A south. The Tribe is allowed to use this land for the purpose of hunting, fishing, frogging, subsistence agriculture and to carry on the Miccosukee tradition.

Miccosukee Tribe concerns regarding LORS relate to water levels at the reservations and in WCA 3 (for pubic health and safety reasons and tree islands impacts) and water quality in the WCA 3. Based on performance measures developed for water levels in WCA 3 and modeling data, the LORS Preferred Alternative would result in no meaningful stage changes in the WCA 3. Regarding water quality effects from Lake Okeechobee releases to WCA 3, there would be no measurable effect from any alternative to the receiving marsh areas in the WCAs. This is primarily due to the STA 3/4's water quality treatment capacity (currently 64,000 acre-feet annual average), given current lake phosphorus levels. As phosphorus levels decline in Lake Okeechobee, more water can be treated in STA 3/4 and delivered south to WCA 3. Reference Section 6.14 for more discussion on water quality effects.

The Corps requested government to government consultation with the Tribe on the LORS by letters dated September 8, 2006 and July 24, 2007. The Corps received comments from the Miccosukee Tribe on the 2006 draft SEIS, as well as the revised draft SEIS, and despite the Corps' requests by e-mail correspondence on October 10 and 17, 2007, a face to face meeting was not scheduled before the time this FSEIS was prepared.

The Seminole Tribe of Florida has six reservations located in Florida. The reservations include Brighton, Tampa, Fort Pierce, Immokalee, Hollywood and Big Cypress. Hollywood is the headquarters location for the Seminole Tribe.

The Seminole Tribe has surface water entitlement rights pursuant to the 1987 Water Rights Compact between the Seminole Tribe of Florida, the State of Florida, and the SFWMD. (Pub. L. No. 100-228, 101 Stat. 1566 and Chapter 87-292 Laws of Florida as codified in section 285.165, Florida Statutes.). Additional documents addressing the Water Rights Compact entitlement provisions have since been executed. These documents include Agreements between the Tribe and SFWMD and a SFWMD Final Order. Of particular interest in this regard is the 1996 Agreement which commits the SFWMD to mitigate impacts to the Tribe's ability to obtain surface water supplies at both the Brighton and Big Cypress Reservations which may be diminished as a result of various activities, including changes in the LORS.

Two reservations of the Seminole Tribe of Florida rely on Lake Okeechobee as a secondary supplemental irrigation supply source for their surface water with specific volumes of water identified for this purpose for the Big Cypress Seminole Reservation and an operational plan addressing drought-water shortage operations for the Brighton Seminole Indian Reservation in the Indian Prairie Basin.

Analysis of the proposed plan shows it may result in the Lake's levels declining to below 10 ft. NGVD on a more frequent basis. This is a concern for both the Brighton and Big Cypress Reservations since both Reservations rely on the Lake, in part, for water supply, and it is difficult to convey water out of the Lake below this level. The Seminole Tribe has raised concerns about the reliability of Lake Okeechobee as a water supply source under the LORS plan. Securing a dependable source of water for the Tribe's reservation is of particular importance considering the Tribe's surface water federal entitlement rights. The Tribe submitted comments on the August 2006 draft SEIS, as well as the June 2007 revised draft SEIS. Corps and SFWMD representatives first met with the Tribe in the fall of 2006 to discuss the Tribe's concerns with the August 2006 draft SEIS. The discussion focused on model analysis of impacts to the Seminole Tribe's water rights and alternative mechanisms to deliver water to the Brighton and Big Cypress Reservations during drought conditions. Since that time the SFWMD has completed analysis of several mechanisms to provide alternative water supply to the Tribe's Reservations in both the short and long-term. Additionally, Corps representatives met with the Tribe on September 19, 2007 in Hollywood, Florida and then with the SFWMD and Tribe representatives on October 1, 2007 in West Palm Beach to discuss proposed short and long-term measures to address the issue at both

Reservations and continue to evaluate alternative short-term and long-term means of delivering water at low Lake levels.

For the Brighton Reservation, various options of securing both short and long-term water supply deliveries to agricultural operations in the Southern Indian Prairie Basin continue to be evaluated and implemented where possible. For example, the SFWMD is currently funding development of an aquifer storage and recovery (ASR) well on the Brighton Reservation as a possible alternative water supply source. However, the proposed ASR well will not be operational until after 2010. Other water source and conveyance options, including deviations to the Lake Istokpoga schedule to provide for additional water supply and modifications to the C-40 canal to augment the pump station G-208 capability, continue to be explored. For the Big Cypress Reservation, SFWMD has installed forward pumps to deliver water from the Lake at lower stages to the Miami Canal. Also, real-time operational decisions made during a declared drought event are made while fully cognizant of the Tribe's water rights.

Simulated Water Supply Performance for the Seminole Tribe Reservations: Brighton and Big Cypress

Simulated water supply effects on the Brighton and Big Cypress Seminole Tribe Reservations are summarized for the percent of water supply demand not met, based on SFWMM PM graphics shown in Appendix E, Figures C-82 through C-85. Unmet demand for the Brighton Reservation is summarized as follows: 3.5 percent for the No Action Alternative; 2.0 percent for Alternative A; 2.1 percent for Alternative B; 2.1 percent for Alternative C; 2.4 percent for Alternative D; and 2.4 percent for Alternative E. Unmet demand for the Big Cypress Reservation is summarized as follows: 4.6 percent for the No Action Alternative; 7.1 percent for Alternative A; 7.3 percent for Alternative B; 7.1 percent for Alternative C; 7.7 percent for Alternative D; and 7.6 percent for Alternative E.

The SFWMM operations for the water supply delivery to the Seminole Reservations, including assumed structures and operational triggers, were not modified for the LORSS simulations. Potential mitigation measures were not modeled in this study as what, if any, measures to be implemented by SFWMD, pursuant to its agreements with the Tribe, have not been decided upon at this time. Modifications to the existing configuration were therefore not able to be included in the LORSS simulations for the No Action Alternative base condition or other LORSS alternatives.

6.20. DRINKING WATER

Currently, Lake Okeechobee provides a primary source of potable water to the cities of Clewiston, Hendry County; South Bay, Belle Glade and Pahokee, Palm Beach County; and Okeechobee, Okeechobee County. The C-43 provides an important source of potable water for Lee County and the City of Ft. Myers. The Corps' goal is to maximize the time the Lake elevation is between 12.5 ft-NGVD and 15.5 ft-NGVD, seasonally, in order to minimize the probability of lake stages exceeding 17.25 feet for public safety and health concerns with HHD. When Lake Okeechobee stages are in the lower bands

of the proposed regulation schedule, releases may occur which are less than "maximum practicable," depending on conditions. The rationale for less than "maximum practicable" releases include reducing the probability of entering the Water Shortage Management band that could impact municipal, industrial and agricultural water supply (based on short-term and long-term forecast) and/or responding to ecological considerations in Lake Okeechobee or the coastal estuaries. Palm Beach County has expressed concerns about the cost increase in treatment of their potable water due to the turbidity levels at the water intake sites at low lake water levels. This concern is being addressed by Palm Beach County with the construction of new treatment facilities that are scheduled to be completed in 2008 which will eliminate the need to use surface water as a primary water source.

6.21. CUMULATIVE EFFECTS

Cumulative impacts are impacts likely to occur due to the Proposed Action or alternatives in combination with other past, present and reasonably foreseeable future actions.

There are many studies/projects identified for the central/southern portion of Florida, which may affect the study area in the future. Many, but not all, of the studies/projects fall under the CERP. Cumulatively, these projects would provide improvements in water deliveries to the coastal estuaries such as the Caloosahatchee and St. Lucie. Some major projects that would directly or indirectly improve the quantity, quality, timing and distribution of water to the Caloosahatchee Estuary are the Southwest Florida Feasibility Study, C-43 Basin Storage Reservoir, and Picayune Strand Hydrologic Restoration. Those directly affecting the St. Lucie Estuary are Indian River Lagoon-South and C-44 Basin Storage Reservoir. Projects directly affecting estuaries and Lake Okeechobee are the Lake Okeechobee Watershed Project and Kissimmee Restoration. The EAA Reservoirs will also benefit the physiographic ecosystems influenced by Lake Okeechobee. These projects and their purposes are summarized below. For details on CERP projects, refer to the CERP website found at: <http://www.evergladesplan.org/>).

The **Southwest Florida Feasibility Study** is in the process of identifying southwest Florida water resources conditions and developing potential solutions to the problems identified. The project area includes the Caloosahatchee and Big Cypress watersheds, and is addressing the health of upland and aquatic ecosystems in this 4,300 square mile area. The major goal is to define the hydrologic linkages among nearly 30 federal, state, or county-managed areas and to coordinate the management and stewardship of these areas. A principal goal for all of southwest Florida's hydrological restoration is the reestablishment of the minimum freshwater flows, and the elimination of freshwater point-source discharges, needed to restore more natural hydrology, i.e. salinity patterns, in the estuaries.

The **C-43 Basin Storage Reservoir** project purpose is to capture Caloosahatchee River Watershed (C-43 basin) runoff and releases from Lake Okeechobee. The reservoir would be designed, in part, to provide water quality benefits in terms of reduced salinity and nutrients in the Caloosahatchee Estuary.

The **Picayune Strand Hydrologic Restoration project** is located in the Big Cypress watershed of the Everglades region, in an area of approximately 94 square miles in southwestern Collier County. The project purpose is to restore and enhance the fish and wildlife habitat, particularly wetlands, by reducing over-drainage. The project would reestablish more natural overland flows and improve the quality of the coastal estuaries by spreading the freshwater discharges more evenly among bays and moderating the large salinity fluctuations currently caused by point discharges from the Faka Union Canal.

The **C-44 Basin Storage Reservoir** is a 10,000 acre reservoir slated to be built in Martin County. The reservoir will be designed to capture local runoff to meet flow distribution goals to the Indian River Lagoon and the St. Lucie Estuary.

The **Indian River Lagoon South Restoration Project** is designed to reverse the impacts of pollution and unnaturally large freshwater flows to the surrounding water bodies. The project will assist in achieving the balance of fresh and salt water in the Indian River Lagoon and St. Lucie Estuary.

The **Lake Okeechobee Watershed Project** will in part address phosphorus loads to the lake and also provide alternative storage locations (reservoirs) so that water levels in the lake can be regulated for greater environmental benefits while still serving water supply and other water resource functions. The LOWP is intended to reduce the phosphorus load by 53 metric tons per year and store approximately 273,000 acre feet of water (SFWMD, 2007). The load reduction will assist in meeting the TMDL goals for Lake Okeechobee.

The **EAA Reservoirs** are designed to capture, store and redistribute freshwater lost to tide and to regulate the quantity, timing and distribution of water for environmental deliveries. The benefit for Lake Okeechobee would be a reduction in flood control releases to the estuaries, improvements of environmental water deliveries to the WCAs, and to provide an alternate source of water (currently the primary source is Lake Okeechobee) to meet agricultural irrigation demands.

The **Kissimmee River Restoration project** is currently undergoing restoration efforts that will return a significant portion of the Kissimmee River to its historic riverbed and flood plain. These actions will provide a more natural fluctuation of water levels in both the upper and lower basins.

The restoration of hydrology from all CERP related projects, but in particular, projects listed above, will produce extensive cumulative beneficial effects to Lake Okeechobee, St. Lucie and Caloosahatchee estuaries, as well as other physiographic regions within the LORSS. Cumulatively, these projects would reduce undesirable freshwater releases from Lake Okeechobee as well as reducing watershed runoff to the estuaries by redirecting or capturing some of these flows. Through this reduction, it's anticipated that a more natural salinity gradient within the estuaries, as well as reducing the fluctuation of salinity caused by freshwater flows, would occur. Water quality

improvement would be expected to occur in Lake Okeechobee, estuaries and greater Everglades, as a result of implementation of the above projects.

In addition to CERP projects, other authorized improvements to the C&SF Project (Modified Water Deliveries [MWD] to ENP and South Dade Canals or C-111) projects are to be completed, which would enable water deliveries for restoration of more natural hydrologic conditions to the Everglades. Together, these projects would enable the re-establishment of the historic Shark River Slough flow-way from WCA-3A through WCA-3B to ENP. Currently, MWD and C-111 are partially completed and are operated in accordance with the Interim Operating Plan (IOP), until the Combined Structural and Operational Plan (CSOP) is implemented. Superseding IOP, was the Interim Structural and Operational Plan (ISOP), which was implemented in 2000. The plans provide the operational protocol to protect the endangered CSSS while providing the additional water deliveries to ENP. All of these plans were or are being developed as temporary solutions until the MWD and the C-111 Projects are complete. When complete, the MWD and C-111 projects would allow for more favorable hydroperiods and water levels in WCA 3 A and B, and ENP.

Other Federal, State, and Local Initiatives affecting the LORS

The following summarizes other initiatives that cumulatively would affect the LORSS. Many initiatives are related to water quality improvement and mandated by laws, statutes, agreements and permits, to assist in environmental restoration efforts underway for central and south Florida.

There are many studies and projects that are directly dealing with water quality issues for Lake Okeechobee. Some of the primary sources of water contamination in the Lake Okeechobee system are suspended solids, nutrients, animal wastes and pesticides. When these substances are present in excess, algal blooms, fish kills, sedimentation, health hazards, aesthetic changes and modifications of species diversity may result. A State act passed in 2000, the Lake Okeechobee Protection Act (LOPA), establishes a restoration and protection program for Lake Okeechobee, which focuses on meeting water quality standards. Reducing phosphorus loads to Lake Okeechobee is an important focus of the LOPA. Other State water quality improvement initiatives are being accomplished through best management practices, surface water improvement and management, pollutant load reduction goal, settlement agreement and consent decree, and Lake Okeechobee and Estuary Recovery (LOER). Through the CWA, EPA has proposed TMDL for the Lake Okeechobee tributaries, which establishes the amount of a pollutant that can be assimilated in a water body.

South of Lake Okeechobee is the State's Everglades Construction Project (construction of over 44,000 acres of STAs), which is currently underway, and will assist in restoration of Lake Okeechobee and its estuaries. The STAs will use naturally occurring biological processes to reduce the levels of phosphorus from Lake Okeechobee, Everglades Agriculture Area, etc. that enter the Everglades. Cumulatively, the Everglades Construction Project would improve the volume, timing and distribution of water

entering the Everglades, which would assist in reducing the volume of undesirable discharges to Caloosahatchee Estuary, St. Lucie Estuary and Lake Worth.

These numerous interagency initiatives are designed to provide measurable and meaningful improvements to water quality and water quantity in Lake Okeechobee and the St. Lucie and Caloosahatchee estuaries. Collectively and cumulatively, these water quality improvement efforts would reduce elevated nutrient levels, reduce the levels of resuspended sediments, and may reduce the rapid expansion of exotic and nuisance plant growth in Lake Okeechobee and other system water bodies. Public health and safety as it relates to the HHD and downstream systems will also benefit cumulatively from a lower lake schedule and projects listed above that provide water storage.

Other state initiatives such as storage of lake water on public/private lands (Section 4.5) and implementation of new Water Shortage Management Plan (2006 draft LOWSM Plan represents one proposal by the SFWMD) would be more immediate benefits to many physiographic regions in the LORSS planning areas. Storage of water, combined with the operational changes of the Preferred Alternative, would benefit the estuaries by reducing high volume freshwater releases, or reduce the duration of those releases. The new Water Shortage Management plan would be used to adjust or modify water supply demands during dry periods. The new Water Shortage Management plan (including utilization of the temporary forward pumps) may reduce the likelihood of adverse effects to water supply, and decrease exceedences/violations of Minimum Flows and Levels (MFL) set for Lake Okeechobee and the estuaries as a result of implementing a lower lake schedule.

6.22. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

6.22.1. IRREVERSIBLE

An irreversible commitment of resources is one in which the ability to use and/or enjoy the resource is lost forever. One example of an irreversible commitment might be the mining of a mineral resource. Implementation of Alternative E would not alter any existing features or landscape. There should be no irreversible commitment of resources as a result of this action.

6.22.2. IRRETRIEVABLE

An irretrievable commitment of resources is one in which, due to decisions to manage the resource for another purpose, opportunities to use or enjoy the resource as they presently exist are lost for a period of time. An example of an irretrievable loss might be where a type of vegetation is lost due to road construction. Implementation of Alternative E would not alter existing features or landscape. There should be no irreversible commitment of resources as a result of this action.

6.23. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

As the proposed action is completely operational, and does not contain any physical features, construction, or addition or removal of structures, and the action is designed

to enhance conditions to the natural environment, there are minimal adverse effects anticipated to the natural and human environment.

6.24. CONFLICTS AND CONTROVERSY

There will always be a level of controversy with any issue related to water management in south Florida, especially as it relates to the LORS. There was much controversy with the Corps' original Preferred Alternative (1bS2-m) in the 2006 draft SEIS. The controversy stemmed largely from the west coast stakeholders and their concern with minimal improvement for the Caloosahatchee Estuary. The Corps took consideration of these concerns in an attempt to improve the 2006 Preferred Alternative schedule. This SEIS is a result of the Corps efforts to improve performance of the Preferred Alternative.

There is controversy with water supply stakeholders about the uncertainty of water supply performance with the recommended plan in conjunction with the SFWMD Lake Okeechobee Water Shortage Management (LOWSM) plan. Consequently, there is concern about the length of the period during which the Corps will operate under this schedule. Among those stakeholders, the Seminole Tribe has concerns about how the state will mitigate for water supply impacts.

6.25. ENVIRONMENTAL COMMITMENTS

Operation Meetings

The Corps is committed to continuing operational meetings with a new regulation schedule. Once a week (currently Tuesday), a group of water managers, scientists and engineers from the Corps, SFWMD, and other agencies meet via telephone conference to discuss the state of the C&SF system and possible operational scenarios. Reports on the ecological and hydrological status of different physiographic areas, such as estuaries and the Everglades, are presented. Under a new regulation schedule, the Corps would continue consulting with the agencies weekly to determine the status of the individual ecosystems in the study area. Much attention from the group centers on the spring season (March–June), which is critical for all ecosystems in the area. For Lake Okeechobee, allowing spring recessions with limited reversals is critical to plants and animals, including nesting and foraging habitat for the endangered snail kite. Additionally, many estuarine dependent species reproduce in the spring. This is a critical period for maintaining certain flow ranges for proper salinity regimes in the estuaries.

Terms and Conditions (Biological Opinion dated October 2007)

1. The Corps will implement an apple snail monitoring program within the littoral zone of Lake Okeechobee. This program should be conducted until the next consultation on the lake's regulation schedule.

2. The Corps will ensure that a vegetation survey is performed in 2010 for Lake Okeechobee in a way that it can be compared to the baseline vegetation data as a measure of change in suitable habitat for the snail kite.

6.26. COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

6.26.1. NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

Environmental information on the action has been compiled and presented in Final SEIS. The project is in compliance with the NEPA.

6.26.2. ENDANGERED SPECIES ACT OF 1973

A species list was requested from NMFS on September 15, 2005. By letter dated August 10, 2006, the Corps initiated consultation with NMFS. The Corps made a "may effect, not likely to adversely affect" determination for the smalltooth sawfish and Johnson's seagrass. The NMFS replied by letter dated September 27, 2006 that additional information would be needed for their evaluation. Additional information was provided in the revised draft SEIS dated June 2007. By letter dated September 11, 2007, the NMFS concurred with the Corps' determination of "may affect, not likely to adversely affect smalltooth sawfish and Johnson's seagrass."

A species list was requested from USFWS on August 29, 2005, and received on September 30, 2005. Informal consultation was initiated with USFWS by letter dated March 8, 2006. Formal consultation was initiated with USFWS by letter dated June 30, 2006, which included a BA of effects on endangered and threatened species. Based on new information, an updated BA was submitted to USFWS on December 15, 2006. The updated BA did not change the Corps' determination of effects on endangered and threatened species. A Biological Opinion dated October 2007 was submitted to the Corps. This action has been fully coordinated under the ESA and is in full compliance with the Act.

6.26.3. FISH AND WILDLIFE COORDINATION ACT of 1958

This action has been coordinated with the USFWS. A final CAR dated October 2007 is included in the final SEIS. This project is in full compliance with the Act.

6.26.4. NATIONAL HISTORIC PRESERVATION ACT OF 1966 (INTER ALIA)

The action has been coordinated with the Florida State Historic Preservation Officer. The action is in compliance with the Act.

6.26.5. CLEAN WATER ACT OF 1972

As the Proposed Action is strictly of an operational nature, and does not involve any new discharge or construction activity, water quality certification from the State of Florida is not required. Furthermore, as there are no structural components contained in the Proposed Action and no dredge and fill operations being considered, a Section 404(b) Evaluation is not appropriate. The action is in compliance with this act.

6.26.6. CLEAN AIR ACT OF 1972

No air quality permits will be required for this action.

6.26.7. COASTAL ZONE MANAGEMENT ACT OF 1972

A Federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this report as *Appendix B*. State consistency review was performed during coordination of the revised draft SEIS. The State has determined that the action is consistent with the Florida CZM Program.

6.26.8. FARMLAND PROTECTION POLICY ACT OF 1981

There would be no conversion of prime or unique farmland to other uses. This Act is not applicable.

6.26.9. WILD AND SCENIC RIVER ACT OF 1968

The Northwest Fork of the Loxahatchee River is designated a Wild and Scenic River. This resource is not expected to be adversely impacted by the Proposed Action. The study is in full compliance with this Act.

6.26.10. MARINE MAMMAL PROTECTION ACT OF 1972

The Proposed Action would not adversely impact marine mammals. Therefore, this action is in compliance with the Act.

6.26.11. ESTUARY PROTECTION ACT OF 1968

The Indian River Lagoon and Charlotte Harbor are part of the National Estuary Program established by Section 320 of the CWA. This action would not adversely affect these estuaries. The action is in compliance with this Act.

6.26.12. FEDERAL WATER PROJECT RECREATION ACT

The effects of the Proposed Action on outdoor recreation have been considered. Benefits to fishing, boating and wildlife viewing should be accrued by implementation of the Proposed Action. Therefore, the action is in compliance with this Act.

6.26.13. FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976

This action has been coordinated with the NMFS and is in compliance with the Act.

6.26.14. SUBMERGED LANDS ACT OF 1953

The action would occur on submerged lands of the State of Florida. The project has been coordinated with the State and is in compliance with the Act.

6.26.15. COASTAL BARRIER RESOURCES ACT AND COASTAL BARRIER IMPROVEMENT ACT OF 1990

There are no designated coastal barrier resources in the project area that would be affected by this action. These Acts are not applicable.

6.26.16. RIVERS AND HARBORS ACT OF 1899

The Proposed Action will not obstruct navigable waters of the United States. The action is in full compliance.

6.26.17. ANADROMOUS FISH CONSERVATION ACT

Anadromous fish species will not be affected. The action has been coordinated with the NMFS and is in compliance with the Act.

6.26.18. MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT

No migratory birds will be adversely affected by the action. The action is in compliance with these Acts.

6.26.19. MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT

The term "dumping" as defined in the Act (3[33 U.S.C. 1402](f)) does not apply to the action proposed. Therefore, the Marine Protection, Research and Sanctuaries Act does not apply to this action.

6.26.20. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

This act requires the preparation of an EFH Assessment and coordination with the NMFS. The Corps received a "no objection" to the action letter from NMFS dated July 24, 2007. This action is in compliance with the Act.

6.26.21. EXECUTIVE ORDER (E.O.) 11990, PROTECTION OF WETLANDS

No wetlands will be affected by the action. This action is in compliance with the goals of this E.O.

6.26.22. E.O. 11988, FLOOD PLAIN MANAGEMENT

The project area is in the base flood plain (100-year flood) and has been evaluated in accordance with this E.O. The action is in compliance.

6.26.23. E.O. 12898, ENVIRONMENTAL JUSTICE

The Proposed Action will not result in adverse health or environmental effects. Any impacts of this action will not be disproportionate toward any minority. The activity does not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin. The activity would not impact "subsistence consumption of fish and wildlife."

6.26.24. E.O. 13089, CORAL REEF PROTECTION

The Proposed Action will not result in adverse impacts to coral reef ecosystems. No coral reef habitats exist within or near the project area. This Act is not applicable.

6.26.25. E.O. 13112, INVASIVE SPECIES

This action does not authorize, fund, or carry out actions that might spread or introduce invasive species.

7. LIST OF PREPARERS

7.1. PREPARERS AND REVIEWERS

NAME	DISCIPLINE	ROLE/RESPONSIBILITY
Yvonne Haberer	Biologist, Corps	NEPA Impact Analysis and Coordination, Document Preparer
Sue Byrd	Everglades Partners Joint Venture (EPJV)	Document Review, Edit and Formatting
Dan Crawford	Hydraulic Engineer, Corps	Hydrologic Modeling
Dave Apple	Engineer, Corps	Plan Formulation
Richard Punnett	Corps Contractor	Hydrologic Modeling
John Zediak	Chief, Water Management Section, , Corps	Operational Guidelines Paper
Kamili Hitchmon	Hydraulic Engineer, Corps	Document Review
Andrew Geller	Hydraulic Engineer, Corps	Operational Guidelines Paper
Logan Wilkinson	Hydraulic Engineer, Corps	Operational Guidelines Paper
Christopher Graham	Economist, Corps	Economic Report
Jeff Morris	Economist, Corps	Economic Report
Jeff Trulick	Biologist, Corps	Plan Formulation
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Kim O'Dell	Sr. Environmental Scientist, SFWMD	Project Manager
Bruce Sharfstein	Lead Environmental Scientist, SFWMD	Evaluator of Lake Ecology Performance Measures
Peter Doering	Sr. Supervising Environmental Scientist, SFWMD	Evaluator of Estuary Performance Measures
Martha Nungesser	Sr. Environmental Scientist, SFWMD	Evaluator of Greater Everglades PMs
Louis Woehlcke	Lead Economist	Evaluator of Water Supply Performance Measures
Patrick Howell	EPJV	Document Review
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Luis Cadavid	Chief Hydrologic Modeler, SFWMD	Document Review
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Eric Bush	Chief, Restoration Planning Section	Document Review

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8. PUBLIC INVOLVEMENT

8.1. SCOPING AND DRAFT SEIS

A scoping letter, dated July 21, 2005, was sent out by the Corps to agencies and interested parties soliciting views, comments, and information about environmental and cultural resources, study objectives and important issues within the study area. A Notice of Intent (NOI) to prepare a draft SEIS appeared in the Federal Register on August 3, 2005. During the 60-day comment period, many written responses were received that represented several issues. These issues were subsequently compiled and infused into the plan formulation process. A sampling of issues resulting from the scoping process are included in Section 1.8. A copy of the Corps' scoping letter and NOI can be found in Appendix H. It should be noted that the 60-day scoping comment period was extended through November 2005 due to the impact of Hurricane Wilma on the south Florida regional communities.

Four public scoping meetings were conducted at the following locations:

- Clewiston October 11, 2005
- Ft. Myers November 14, 2005
- Okeechobee November 15, 2005
- Stuart November 17, 2005

In addition to the scoping meetings, public workshops were held during the planning phase of the regulation schedule development. The first workshop was held at the Okeechobee Civic Center in Okeechobee, Florida on February 22, 2006. The purpose of the public workshop was to present the LORS alternatives under consideration. Interested individuals, groups, and agencies were invited to attend and were given an opportunity to comment and ask questions. The workshop was video taped and can be found on the Corps' Jacksonville District webpage at: www.saj.usace.army.mil. A second round of workshops was held on the following dates: July 11, 2006 at John Boy Auditorium in Clewiston, Florida; July 12, 2006 at the Lee County Commission Chambers in Fort Myers, Florida; and July 13, 2006 at Indian River Community College in Stuart, Florida. The purpose of the public workshops was to inform the public of the tentative selected plan (or Preferred Alternative regulation schedule). Numerous presentations to the Water Resources Advisory Commission (WRAC)/Lake Okeechobee Committee were conducted throughout the study process.

A Notice of Availability (NOA) of the draft SEIS appeared in the Federal Register on August 18, 2006. Copies of the draft SEIS were mailed to agencies and individuals, and provided to local libraries for viewing. Additionally, the draft SEIS was uploaded to the Corps environmental webpage for public viewing. Separate letters (dated September 8, 2006) were provided to the Miccosukee and Seminole Indian Tribes requesting consultation on the draft SEIS. A series of four public meetings were held in 2006 after release of the draft SEIS. Meetings took place in Stuart on September 12,

Okeechobee on September 13, Ft. Myers on September 14, and Clewiston on September 18.

In response to public input on the Corps' Preferred Alternative presented in the August 2006 draft SEIS, additional plan formulation and modeling took place to improve the performance of the 2006 Preferred Alternative. Due to the updated modeling information and improvements to the 2006 Preferred Alternative that led to three new alternatives, it is necessary to disclose the environmental effects of this effort as it relates to benefits and impacts. It was decided to disclose this information in a revised draft SEIS, instead of finalizing the August 2006 draft SEIS. Most importantly, the draft SEIS incorporated the public comments of the August 2006 document. Agency and public comment letters received on the 2006 draft SEIS were presented in the revised draft SEIS, Appendix H.

After release of the revised draft SEIS on July 6, 2007 (Federal Register NOA date), the Corps held a series of public meetings to provide the public an opportunity to comment on the revised plan. Meetings were held in Stewart on August 7, Ft. Myers on August 8, Belle Glade on August 13, and Okeechobee on August 14, 2007. During the public comment period on the revised draft SEIS, many comments were received. Those comments, and the Corps' responses, can be found in Appendix H.

8.2. AGENCY COORDINATION

Coordination with local, state and federal agencies was achieved by inviting staff of those agencies to participate as team members. Team members were invited to participate in weekly team meetings via teleconference and video conference throughout the planning process of the study. The EPA, USFWS, NMFS, FDEP, FFWCC, SFWMD, Seminole Tribe of Florida, Lake Worth Drainage District, city governments of Lee County, Martin County, City of Sanibel, Broward County, and Miami-Dade County Office of Water Management, all took the initiative to participate and contribute one or more staff to the study team. The issues and concerns of these agencies and governments were continuously a part of study team activities.

8.3. LIST OF STATEMENT RECIPIENTS (REVISED DRAFT SEIS)

Copies of the final SEIS were sent to local, state, and federal agencies, interested parties and individuals for review and comment in accordance with the Council on Environmental Quality's (CEQ) NEPA regulations and related Corps guidance. A complete mailing list can be found in Appendix H. In addition, the final SEIS can be found at the following Corps website:

<http://planning.saj.usace.army.mil/envdocs/envdocsb.htm>.

8.4. COMMENTS RECEIVED AND RESPONSE

This final SEIS incorporates the public comments and concerns of the revised draft SEIS dated June 2007. Agency and public comment letters received on the revised draft SEIS, and the Corps' responses to those comments, are located in Appendix H.

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APPENDIX A

Proposed Revisions to Lake Okeechobee Operational Guidance

**U.S. Army Corps of Engineers
Jacksonville District**

November 2007

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General Overview

The U.S. Army Corps of Engineers (USACE) is responsible for management of the water resources contained within Herbert Hoover Dike (HHD) and for the development of regulations for operation of Lake Okeechobee's outlet structures. Water management operations at Lake Okeechobee are performed to ensure that Congressionally-authorized project purposes are met. The Congressionally-authorized project purposes for Lake Okeechobee include: flood control; navigation; water supply for Everglades National Park (ENP), salinity control, regional groundwater control, agricultural irrigation, municipalities and industry; enhancement of fish and wildlife; and recreation.

The purpose of this operational guidance document is to describe and explain the implementation of the proposed water management operational changes to Lake Okeechobee and the Everglades Agricultural Area. These changes will be included in the revised Lake Okeechobee and Everglades Agricultural Area Water Control Plan (WCP). This proposed water management operational guidance pertains to the Lake Okeechobee Regulation Schedule (LORS) which defines allowable releases to the Water Conservation Areas (WCAs) and to tide (estuaries). The water management operational guidance pertaining to operations that are not prescribed by the regulation schedule and which are utilized in accordance with the current WCP (Lake Okeechobee and Everglades Agricultural Area, July 2000) will remain in effect and be incorporated into the revised WCP. The revised Lake Okeechobee and Everglades Agricultural Area WCP is currently scheduled to be approved for implementation after the Lake Okeechobee Regulation Schedule Study Supplemental Environmental Impact Statement (LORSS SEIS) process has been completed.

Lake Okeechobee Regulation Schedule

The regulation schedule is a tool used by water managers to meet Congressionally-authorized project purposes. A regulation schedule attempts to meet all functional objectives of the particular project, acting separately or in combination with other projects in a system. The regulation schedule has been, and will continue to be, designed to balance multiple, and often competing, project purposes and objectives. Managing for better performance of one objective often lessens the effectiveness of performance of competing objectives. For example, higher regulation schedules tend to benefit water supply, but may increase the risk to public health and safety, and can harm the ecology of the lake. Lower lake schedules may produce lake levels more desirable for the lake ecology and improved flood protection, but reduce water supply potential. Lower lake schedules may also harm the ecology of the lake during extended dry periods and downstream estuaries during extended wet periods. Therefore, the LORS is not developed to optimize performance of any single project purpose, but rather balances the performance of the multiple project purposes. The regulation schedule contains bands which vary with the time of year. Releases are outlined by flowcharts that define the allowable releases by structure within each band.

Though water supply is a project purpose, water supply release volumes are not prescribed by this regulation schedule. However, water supply releases are made to meet downstream

demands that can include agricultural irrigation, municipal and industrial needs, estuary and other environmental water supply needs.

Lake Okeechobee Regulation Schedule Study

The current Lake Okeechobee and Everglades Agricultural Area WCP includes the existing Lake Okeechobee interim regulation schedule (shown in Figure 1), commonly referred as “Water Supply and Environment (WSE) regulation schedule”, which has been in use since July 2000 (located at <http://www.saj.usace.army.mil/h2o/lib/documents/WSE/index.html>). LORSS was initiated to address high lake levels, high estuarine discharges, estuary ecosystem conditions, and lake ecology conditions that occurred during the 2003 to 2005 time period. The LORSS considered the back-to-back historically significant 2004 and 2005 hurricane seasons’ effects on the recognized structural integrity issues of HHD along with effects to other project purposes.

The LORSS resulted in the development of several alternative regulation schedules, including the Tentatively Selected Plan (TSP). The TSP is a completely new regulation schedule with new breakpoints for all bands, new release magnitudes in many bands, and new forecasting indices. Both WSE and the TSP are based on WSE’s Operational Guidance that includes: “Part 1: Define Lake Okeechobee Discharges to the WCAs” and “Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)”. Parts 1 and 2 of the WSE Decision Tree are shown on Figure 2 and Figure 3, respectively. The South Florida Water Management District (SFWMD) and USACE 1999 report; “The Lake Okeechobee WSE Operational Guidelines” located in the July 2000 LORS Environmental Impact Statement (EIS) defines and describes the development of WSE.

The Preferred Alternative was identified to be effective at decreasing the risk to public health and safety, reducing the number of high-volume discharges to the estuaries, and providing critical flexibility to perform water management operations. Selection of the TSP included analysis of South Florida Water Management Model (SFWMM also known as the 2x2) output. The SFWMM was used to simulate the performance of the alternative regulation schedules over a 36-year period of record, based on climate and hydrometeorologic data from 1965 to 2000.

Daily water management operational decisions will consider all conditions/data available and climatologic conditions during the 1965 to 2000 period which are representative of a wide range of historic conditions, but are not a predictor of future climatologic conditions. The new Lake Okeechobee/EAA WCP will need to contain flexibility to manage for high lake levels, including scenarios not experienced during the period of record. Water managers make decisions based on the best available information, given the uncertain nature of future events.

The TSP simulation resulted in a one-day average-daily peak lake elevation of 17.33 feet, National Geodetic Vertical Datum of 1929 (NGVD). High lake levels are of importance due to the known integrity issues with HHD and USACE’s responsibility to provide for public health and safety. In 1998, the combined probability for a breach at HHD, as shown in Table 1, was recognized as a concern by USACE. The probabilities in Table 1 assumed an unidentified and unaddressed integrity issue. USACE currently has both short-term as well as long-term solutions

addressing this concern. For additional information on HHD, please visit the USACE Jacksonville District webpage at: <http://www.saj.usace.army.mil/>

Table 1

Probability of HHD Breach at Selected Lake Elevations
From Table H-10.2, 1998 HHD Major Rehabilitation Report

Lake Elevation (ft., NGVD)	Combined Probability Of HHD Breach (%)
15	1
16	3
17	11
18	45
21	100

Summary of the Tentatively Selected Plan

The Preferred Alternative resulted in proposed water management operational guidance to be used on a daily basis in the management of Lake Okeechobee. The proposed operational guidance includes: 2007 Lake Okeechobee Interim Regulation Schedule Part A through D (Figures 4 through 7, respectively), Tributary Hydrologic Conditions (THCs), weather forecasts, climate-based hydrologic outlooks, and historical as well as projected lake level information.

Through the Preferred Alternative, management of Lake Okeechobee water levels and determination of Lake Okeechobee releases to the WCAs and to tide (estuaries) is based on seasonally varying lake elevations divided into three bands as shown on the proposed 2007 Lake Okeechobee Interim Regulation Schedule Part A (Figure 4). These bands include "High Lake Management" (top band on Figure 4), "Operational" (middle band on Figure 4), and "Water Shortage Management" (bottom band on Figure 4). The High Lake Management Band is meant to address public health and safety, especially related to the structural integrity of HHD by providing the ability to make releases up to the maximum capacity that lake outlets will allow. The Operational Band is meant to facilitate authorized project purposes by providing the ability to make releases of various volumes, including no release; Lake Okeechobee outlet canals should be maintained within their optimum water management elevations. The Water Shortage Management Band pertains to low lake levels which necessitate rationing water supplies; Lake Okeechobee outlet canals may be maintained below their optimum water management elevations. The water supply releases made within this band are made according to the SFWMD's draft Lake Okeechobee Water Shortage Management Plan (LOWSM).

The 2007 Lake Okeechobee Interim Regulation Schedule Part B (Figure 5) further defines the bands of the regulation schedule. In Part B, the Operational Band is subdivided into additional bands and sub-bands that are directly related to defining allowable Lake Okeechobee releases to the WCAs and to tide (estuaries). In general as lake levels rise through the higher sub-bands, the allowable release rates increase.

Evaluation of the Preferred Alternative over the period of record (1965 to 2000) shows that the proposed regulation schedule releases to the WCAs and to the estuaries will reduce the likelihood of lake levels that both increase the probability of a breach of the HHD and also contribute to poor ecological conditions within Lake Okeechobee. For Lake Okeechobee, a high lake level can lead to the decline of emergent and submerged vegetation which is essential habitat for the lake's fish and wildlife populations.

The Preferred Alternative provides the ability to make long-term, low-volume releases to the Caloosahatchee Estuary, St. Lucie Estuary, and WCAs. These releases include low-volume pulse releases and base flow releases to the Caloosahatchee and St. Lucie estuaries that allow Lake Okeechobee to be maintained at more desirable levels throughout the year. A pulse release attempts to simulate a natural rainstorm event within the basins. The receiving body would respond to the pulse release in a similar fashion as if a rainstorm had occurred in the upstream watershed. Although an average flow rate is targeted for the duration of the pulse release, daily releases vary. The pulse releases and base flow releases are intended to regulate lake levels and reduce the potential for future prolonged high-volume releases to the estuaries. The base flow releases also provide a benefit of maintaining desirable salinity levels in the estuaries. By regulating lake levels, these low-volume releases improve public health and safety performance by reducing risk to the HHD and provide improved benefits for the health of Lake Okeechobee and the estuaries.

General Comparison of the Tentatively Selected Plan to Water Supply Environment

The TSP includes the Lake Okeechobee Management Bands and Sub-Bands shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part B (Figure 5), and the release guidance, Part C (Figure 6) and Part D (Figure 7). The differences between the Decision Trees for WSE and the TSP's 2007 Lake Okeechobee Interim Regulation Schedule Parts C and D are shown in blue on Figures 6 and 7. As with WSE, the Preferred Alternative utilizes climate-based hydrologic outlooks that may result in a release less than the maximum allowable within a given band when Lake Okeechobee is within the High, Intermediate, or Low Sub-Bands of the Operational Band. The use of hydrologic outlooks allows releases to be made that are commensurate with expected inflow conditions. For example, if the hydrologic outlook is relatively dry, then releases can be less than the maximum allowable within a given band.

The TSP's THCs shown in blue on Figures 6 and 7 have been improved to provide a more comprehensive representation of hydrologic conditions in the Lake Okeechobee watershed. THCs used with WSE only utilized average historical evapotranspiration and excluded rainfall over Lake Okeechobee. As proposed, the THC within Figures 6 and 7 now utilizes the Palmer Index from the National Weather Service and the calculated Lake Okeechobee Net Inflow (Table 2). The Palmer Index depends on temperature, rainfall and soil moisture data, and represents hydrologic conditions such as a drought, or an abnormal dry, or an abnormal wet state. The second THC is the Lake Okeechobee Net Inflow. Net Inflow is defined as rainfall minus evapotranspiration plus lake inflows. WSE used the S-65E inflow as a THC. The TSP's use of the Net Inflow THC accounts for all inflows to, and direct rainfall over Lake Okeechobee. The wettest of the two indicators describes the current tributary condition.

Similar to WSE, the TSP's release guidance (Part D, Figure 7) includes the use of weather forecasts and climate-based hydrologic outlooks as represented by the terms "Seasonal Climate Outlook", "Meteorological Forecast", and "Multi-Seasonal Climate Outlook." Meteorological forecasts are short-term (typically days to weeks) whereas climate outlooks are longer term (months to a year). The climate-based hydrologic outlook is known as the Lake Okeechobee Net Inflow Outlook (LONINO). The seasonal LONINO (six-month outlook) and multi-seasonal LONINO (up to 12-month outlook) are based on historical net inflow data and climate outlooks provided by National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC). The use of these forecasts and outlooks will continue with the implementation of the TSP.

The WSE Decision Tree did not consider actual lake level rise or an anticipated or projected lake level. As proposed, Figure 7 now includes "Lake level projected to rise to" in the High and Intermediate Sub-Bands of the Operational Band to allow quicker implementation of lake releases to slow projected rapid rates-of-rise.

As was the practice for WSE, the TSP includes continuous releases at various volumes, including pulse releases. In a similar manner as WSE, actual releases to be implemented may be performed in a pulse release to simulate natural hydrologic conditions, such as a rainfall event.

The TSP references pulse releases to the Caloosahatchee Estuary at S-79; WSE referenced pulse releases at Lake Okeechobee through S-77. By referencing pulse releases at S-79, local basin runoff is considered when determining the necessary supplemental release at S-77. This achieves pulse releases that are more sensitive to the estuary. This new operation is also consistent with the current pulse release operation to the St. Lucie Estuary at S-80.

Unlike WSE, the TSP provides a base flow release to the estuaries; up to 450 cubic feet per second (cfs) can be made at S-79 and up to 200 cfs can be made at S-80. These base flow releases also consider basin runoff and Lake Okeechobee releases can be made when basin runoff is less than the base flow target. Base flow releases are intended to regulate lake levels and reduce the potential for future prolonged high-volume releases to the estuaries. The base flow releases also provide a benefit of maintaining desirable salinity levels in the estuaries.

Proposed Operational Guidance

The Operational Guidance establishes the allowable quantity, timing, and duration of releases from Lake Okeechobee to the WCAs and to tide (estuaries). Water management decisions will utilize the 2007 Lake Okeechobee Interim Regulation Schedule Parts A through D (Figures 4 through 7) to provide guidance on releases from Lake Okeechobee. Information shown on Part C and Part D (Figures 6 and 7) is utilized to establish the allowable releases to the WCAs and the allowable releases to tide (estuaries), respectively.

In January 2007, the SFWMD Governing Board passed a resolution requesting the Corps to take into consideration increased storage capacity on SFWMD public and private lands in the Okeechobee Watershed to receive Lake Okeechobee water releases. A copy of the SFWMD resolution and past correspondence is provided in Appendix H. The SFWMD lands for storage,

as described in the resolution, would be utilized to achieve a more refined balance between the competing needs of Lake Okeechobee and estuarine ecosystems, flood control and water supply. The Corps strongly supports this state initiative and continues to work with SFWMD to utilize their public/private lands for Lake Okeechobee water storage in conjunction with operation of the Preferred Alternative. When the Operational Guidance and/or basin conditions between Lake Okeechobee and the estuaries result in flows deemed undesirable by SFWMD to the estuaries, the SFWMD may seek to store Lake Okeechobee water on available SFWMD designated lands. As Comprehensive Everglades Restoration Plan (CERP) reservoirs designed to receive Lake Okeechobee releases become available, they will be operated according to the operational guidance established for those projects. These efforts are intended to reduce undesirable lake releases to the estuaries by first making lake releases to alternative storage areas to minimize flows that are above the estuary's biologically-derived maximum flow criteria.

The "Lake level projected to rise to" phrase in the Lake Okeechobee Operational Guidance to Tide (Figure 7) can be determined on a daily basis. Information to be considered includes, but is not necessarily limited to, the following variables: climate forecasts, release constraints due to downstream conditions, actual lake level rate of rise, historical lake levels, and the state of the Central and Southern Florida (C&SF) Project (including the availability of new facilities proposed by the CERP).

Lake Okeechobee Management Bands

The proposed operational guidance for management of the Lake Okeechobee water levels and outlet canals has three distinct bands defined by seasonal fluctuations of the lake level (Figure 4). Each management band is designed to achieve specific objectives consistent with Congressionally-authorized purposes for Lake Okeechobee. The bottom band, at the lower lake levels, is the Water Shortage Management Band. In this band, water in Lake Okeechobee will be managed in accordance with the Water Shortage Plan established by SFWMD. Outlet canals may be maintained below their optimum water management elevations in this band. The top band, at the higher lake levels, is the High Lake Management Band. The goal for lake management within this band is to quickly lower high lake levels. This will make lake storage available for use during the next rainfall event, to reduce impacts on Lake Okeechobee's submerged aquatic vegetation and to reduce the risk to public health and safety, including but not limited to HHD integrity issues; outlet canals may be maintained above their optimum water management elevations in this band. The middle and largest band is the Operational Band, which includes several sub-bands (High, Intermediate, Low, Base Flow, and Beneficial Use Sub-Bands). It is anticipated that the majority of time, lake levels will be within the Operational Band, and Lake Okeechobee would be managed according to the operational criteria established for the sub-bands of the Operational Band, including provisions to meet water supply demands (for ENP, salinity control, regional groundwater control, agricultural irrigation, municipalities, and industry. Outlet canals should be maintained within their optimum water management elevations in this band.

Within the High, Intermediate, Low, and Base Flow Sub-Bands, the allowable release from Lake Okeechobee to the WCAs is defined by lake level, hydrologic conditions, effect of desired release on the Everglades, treatment capacity of Storm Water Treatment Areas (STAs), and

downstream WCA level(s), as well as long-term climate-based hydrologic outlooks (Figure 6). Also within the Operational Band and its sub-bands, the allowable release from Lake Okeechobee to the estuaries is defined by lake level, the trend of the lake level, hydrologic conditions, short-term weather forecasts, and long-term climate-based hydrologic outlooks (Figure 7). A detailed description of the management bands follows.

Water Shortage Management Band—varies seasonally between 9.7 to 13.0 ft., NGVD and below. Operations in this band are governed by the SFWMD's LOWSM (**NOTE: draft Water Shortage Management Band elevations may change upon completion of SFWMD's rule making process.**). The goal of this band is to manage existing water supply contained within Lake Okeechobee in accordance with SFWMD rules and guidance.

High Lake Management Band—varies seasonally between elevations 16.0 and 17.25 ft., NGVD and above. The goal of this band is to reduce the risk to public health and safety and to make releases to lower the lake below the High Lake Management Band as soon as possible. In this High Lake Management Band, it is of the utmost importance that the lake level be reduced as rapidly as possible to make storage available for the next possible rainfall event, to relieve stress on the HHD, and to reduce impacts on Lake Okeechobee's littoral zone. Releases up to the maximum discharge capacity will be made to tide and up to maximum practicable discharges will be pumped to the WCAs and made available to CERP impoundments (as they become available). In an effort to reduce undesirable lake releases to the estuaries, Lake Okeechobee water will also be made available to the SFWMD for their use to store on lands designated by SFWMD (as they become available). Within the High Lake Management Band, the allowable release from Lake Okeechobee to the WCAs and to the estuaries is defined by the lake level as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part C and Part D (Figures 6 and 7), respectively. Actual rates of release from Lake Okeechobee will vary depending on but not limited to downstream channel conditions, estuary conditions, conditions in the WCAs, and conditions in the STAs. Although unlikely to be required due to wet conditions that are likely to exist when lake levels are within this band, Lake Okeechobee releases to meet water supply demands (for ENP, salinity control, regional groundwater control, agricultural irrigation, municipalities, industry, and the environment) may be made at any time within the High Lake Management Band.

Operational Band—the largest management band varies seasonally between 9.7 ft. at its lowest point and 17.25 ft., NGVD at its highest point. (**NOTE: draft Water Shortage Management Band elevations may change upon completion of SFWMD's rule making process which would raise the bottom of the Operational Band-9.7 ft.**) The goal of the Operational Band is to manage the lake stage to balance all authorized project purposes. This involves use of flood control releases, environmental releases, base flow releases, and water supply releases. In an effort to reduce undesirable lake releases to the estuaries, Lake Okeechobee water may be stored in CERP reservoirs (as they become available) or SFWMD may seek to store Lake Okeechobee water on available SFWMD designated lands. The USACE will coordinate operations with the SFWMD as necessary. For Lake Okeechobee, an environmental release can be considered as a release from Lake Okeechobee to benefit the lake ecosystem, downstream ecosystems, and/or upstream ecosystems. For Lake Okeechobee, a base flow release to the Caloosahatchee Estuary is a release from Lake Okeechobee at S-77 to achieve a 450 cfs flow at S-79. A base flow

release to the St. Lucie Estuary is a release at S-308 to achieve a 200 cfs flow at S-80. When conducting base flow releases, flows up to 650 cfs can be distributed East and West as needed to minimize impacts or provide additional benefits. Very dry THCs may require that releases to tide (estuaries) be discontinued. For Lake Okeechobee, a water supply release can be considered a release from Lake Okeechobee to meet water supply demands (for ENP, salinity control, regional groundwater control, agricultural irrigation, municipalities, industry and the environment). Lake Okeechobee releases to meet water supply demands may be made at any time within the Operational Band. Within the Operational Band, several sub-bands have been established to further define lake releases. As described below, these bands include the Beneficial Use Sub-Band, Base Flow Sub-Band, Low Sub-Band, Intermediate Sub-Band, and High Sub-Band.

Beneficial Use Sub-Band: This sub-band varies seasonally between elevation 9.7 ft. and 13.0 ft., NGVD at its highest point. (**NOTE: draft Water Shortage Management Band elevations may change upon completion of SFWMD's rule making process which would raise the bottom of the Beneficial Use Sub-Band-9.7 ft.**). Except for navigation, SFWMD allocates water to various users in this sub-band. Navigation can typically be supported by releases from Lake Okeechobee that are conducted for other authorized project purposes. Fish and wildlife enhancement and/or water supply deliveries for environmental needs may involve conducting an environmental release from Lake Okeechobee through the SFWMD's "Adaptive Protocols" or other SFWMD authorities.

Base Flow Sub-Band: This sub-band varies seasonally between elevation 12.6 ft. and 14.5 ft., NGVD. In this band, the allowable release from Lake Okeechobee to the WCAs is defined by lake level, hydrologic conditions, effect of desired release on the Everglades, treatment capacity of STAs, downstream WCA level(s), THCs, and climate-based hydrologic outlooks as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part D (Figure 7). Also in this sub-band, continuous, low-volume releases can be made to the Caloosahatchee Estuary and the St. Lucie Estuary. Base flow limits are defined as up to 450 cfs measured at S-79, and up to 200 cfs measured at S-80. If the basin runoff between Lake Okeechobee and the estuary is less than this "base flow", then Lake Okeechobee releases are made to supplement the difference. These base flow releases of excess lake water may have environmental benefits to the estuaries and help to reduce the chances of subsequent high volume discharges. In addition, the SFWMD may allocate water to the environment through its "Adaptive Protocols" or other SFWMD authorities.

Low Sub-Band: This sub-band varies seasonally between elevation 13.0 ft. and 16.25 ft., NGVD. In this sub-band, operations for releases to the WCAs and base flow to the estuaries will be conducted consistent with the Base Flow Sub-Band. Lake Okeechobee releases to the estuaries that are greater than base flow are allowed within this sub-band and are defined by lake level, hydrologic conditions, lake level's distance from the Intermediate Sub-Band, THCs, and climate-based hydrologic outlooks as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part D (Figure 7). As shown on Part B, this sub-band was divided into thirds (Upper Range, Middle Range, Lower Range). Within the Upper Range, the pulse release to the Caloosahatchee Estuary is up to 3000 cfs while to the St. Lucie Estuary it is up to 1170 cfs (3000/1170). The pulse release in the Middle Range and the Lower Range is 2500/950 and 2000/730, respectively. Within the Low Sub-Band, the release from Lake Okeechobee to the

WCAs is defined by lake level, THCs, effect of desired release on the Everglades, downstream WCA level(s), and the multi-seasonal climate-based hydrologic outlook as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part C (Figure 6). The maximum allowable lake releases to the WCAs and estuaries is provided as follows:

- (1) To WCAs—When THCs and the multi-seasonal climate/hydrologic outlook are not in their dry classifications, then up to maximum practicable release to the WCAs are allowable if the release is beneficial to, or will result in minimum Everglades impacts. Both the quantity and quality of Lake Okeechobee water will be considered.
- (2) To Estuaries—When tributary conditions are very wet, the lake level is within one foot of the Intermediate Sub-Band, and the seasonal climate forecast is very wet, then lake releases up to 4000 cfs at S-77 and up to 1800 cfs at S-80 (4000/1800) are allowable.
- (3) To Estuaries—When the lake level is not within one foot of the Intermediate Sub-Band, or tributary conditions are not very wet, and the multi-seasonal climate/hydrologic outlook is wet, then lake releases up to 3000 cfs at S-79 and up to 1170 cfs at S-80 (3000/1170) are allowable. These releases are intended to be made in a pulse release that is sensitive to the estuarine environment.

Intermediate Sub-Band: This sub-band varies seasonally between elevation 15.0 ft. to elevation 16.88 ft., NGVD. In this sub-band, operations for base flow to the estuaries will be conducted consistent with the Base Flow Sub-Band. Lake Okeechobee releases to the estuaries that are greater than base flow are allowed within this sub-band and are defined by lake level, THCs, the projected rise of Lake Okeechobee, short term meteorological forecasts, seasonal hydrologic outlooks, and climate-based hydrologic outlooks as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part D (Figure 7). The allowable release from Lake Okeechobee to the WCAs is defined by lake level and downstream WCA level(s), as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part C (Figure 6). The maximum allowable lake releases to the WCAs and estuaries is provided as follows:

- (1) To WCAs—When all downstream WCAs are less than a quarter of a foot above the maximum elevation of their regulation schedules, then up to maximum practicable release to the WCAs are allowable. Downstream WCAs refer to the WCAs downstream of the WCA receiving Lake Okeechobee discharges. For example, if it is desired to make a release to WCA-3A (via STA-3/4), then WCA-1 and WCA-2A water levels do not constrain the release to WCA-3A since they are upstream of WCA-3A. However, if it is desired to make a release to WCA-2A (via STA-3/4), and if the WCA-3A water level was higher than a quarter of a foot above the maximum of its regulation schedule, then no release to WCA-2A would be made.
- (2) To Estuaries—When tributary conditions are very wet and the lake level is projected to rise into the High Sub-Band, lake releases up to 6500 cfs at S-77 and up to 2800 cfs at S-80 (6500/2800) are allowable.

High Sub-Band: This sub-band varies seasonally between elevation 15.5 ft. at its lowest point and elevation 17.25 ft., NGVD. In this sub-band, releases to the Caloosahatchee Estuary of up to 3000 cfs measured at S-79, and up to 1170 cfs to the St. Lucie Estuary measured at S-80, can always be made for management of the lake level. The allowable lake releases to the estuaries

are defined by lake level, THCs, the projected rise of the lake, short term weather forecasts, and the seasonal climate/hydrologic outlook as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part D (Figure 7). The allowable release from Lake Okeechobee to the WCAs is defined by lake level and downstream WCA level(s), as shown on the 2007 Lake Okeechobee Interim Regulation Schedule Part C (Figure 6). The maximum allowable lake releases to the WCAs and estuaries is provided as follows:

- (1) To WCAs-When all downstream WCAs are less than a quarter of a foot above the maximum elevation of their regulation schedules, then up to maximum practicable release to the WCAs are allowable.
- (2) To Estuaries-When THCs are very wet and the lake level is projected to rise into the High Lake Management Band, then lake releases up to maximum discharge capacity are allowable.

Make-up Release Description

Historically, the planned Lake Okeechobee releases to tide (estuaries) have been subject to reduction or prevention by downstream conditions such as downstream local basin runoff, the tidal cycle, tidal storm surge, and spawning in the estuaries. Similarly, planned Lake Okeechobee releases to the WCAs have also been limited by high water levels in the WCAs, STA treatment capacity limits, and limited or no conveyance capacity in the primary canals within the Everglades Agricultural Area. When these conditions have occurred in the past, the releases have been delayed or discontinued to prevent adverse effects downstream from Lake Okeechobee. To address this issue, proposed operational guidance includes conducting releases from Lake Okeechobee to tide and/or to the WCAs (via STAs) to make up releases that were previously reduced or prevented. These make-up releases from Lake Okeechobee to tide (estuaries) and WCAs will occur as soon as possible and may occur when Parts C and D (Figures 6 and 7) do not allow releases or prescribe a lower volume release. The lake make-up releases to tide (estuaries) would be limited to a pulse release from Lake Okeechobee not to exceed 2800 cfs measured at S-79, and 2000 cfs at the St. Lucie Estuary when the lake level is below the Intermediate Sub-Band. This 2000 cfs at the St Lucie Estuary includes releases from all C&SF Project structures that discharge into the St Lucie Estuary.

If an evaluation leads to implementation of a make up release, the make up release volume will be equal to or less than the volume of water that was reduced or prevented. The make up releases would essentially allow the ability to postpone Lake Okeechobee releases. The make up release may or may not be implemented, conditions will be monitored to determine the need to implement.

Decision-Making Process

The decision-making process for Lake Okeechobee water management operations considers all Congressionally-authorized project purposes. The decision-making process to determine quantity, timing, and duration of the potential release from Lake Okeechobee includes consideration of various information related to water management. This information includes

but is not necessarily limited to: C&SF Project conditions, historical lake levels, estuary conditions/needs, lake ecology conditions/needs, WCA water levels, STA available capacity, current climate conditions, climate forecasts, hydrologic outlooks, projected lake level rise/recession, and water supply conditions/needs.

Part A of the 2007 Lake Okeechobee Interim Regulation Schedule (Figure 4) can be considered a starting point in the decision-making process for Lake Okeechobee water management operations. Part A allows a quick visual determination of which of the general management bands applies to the current lake stage.

Use of the 2007 Lake Okeechobee Interim Regulation Schedule Parts B through D (Figures 5 through 7) will result in the determination of releases from Lake Okeechobee. The elevation guidelines include appropriate variations by season to conform to competing project purposes. As with WSE, recreation and navigation is provided for when water is available and/or through releases conducted for other project purposes.

The release to be implemented will be limited to the allowable release determined from Part C and Part D (Figures 6 and 7), except as noted in the Make-up Release Description. Releases can vary up to the allowable release based on consideration of current and anticipated conditions/needs stated in the first paragraph of this section. This process allows for the quantity, timing, and duration of the releases to be performed to address the competing needs associated with water resources and the Congressionally-authorized project purposes.

When operating near band and sub-band limits, up to 30-day forecasts will be made and releases will be scheduled to lower or maintain Lake Okeechobee at the desired level during the 30-day period. Scheduling of releases may include the adjustment of band/sub-band limits when determining the release to implement. Factors considered in adjusting the band/sub-band limits would include but not be limited to: availability of STA treatment capacity, SFWMD designated lands, CERP reservoirs, and the condition of tributary basins. The band/sub-band adjustment is meant to transition into and out of sub-bands by allowing flows to gradually increase or decrease between sub-bands. An example of this adjustment would be: a condition above is occurring, lake level is 0.2 feet below the Intermediate Sub-Band and projected to rise into the Intermediate Sub-Band, then the allowable Lake Okeechobee release would be determined by following Part D with the lake level considered to be in the Intermediate Sub-Band (not 0.2 feet below the Intermediate Sub-Band).

Additional Operational Flexibility

It is anticipated that future events similar to those experienced over the period of record (1965-2000) will be effectively managed by the TSP. The TSP was also simulated for the 2001 through 2005 period, and deemed effective for managing high lake elevations under this set of conditions. Occasionally, additional operational flexibility will be used to address circumstances (i.e., hydrologic conditions, lake levels, spawning in the estuaries and downstream runoff) that were not evaluated in the TSP for the period of record. Additional operational flexibility provides water managers the ability to consider releases from Lake Okeechobee to the WCAs and to tide (estuaries) to minimize damages or to meet project purposes when the 2007 Lake

Okeechobee Interim Regulation Schedule Parts A through D (Figures 4 through 7) are not effective at managing lake levels consistent with the intent of the TSP.

Release decisions will take into account the estuary's biologically-derived maximum flow, future water supply demands, C&SF Project system-wide conditions, and lake ecological conditions, as appropriate. Consideration of the concern for public health and safety is the USACE's highest priority. Once implemented, releases will be discontinued when the conditions that prompted them have ceased or the desired outcome is achieved. Based upon the evaluation of historical conditions and the expected performance of the TSP, it is anticipated that use of additional operational flexibility will be infrequent.

Each event to be addressed by additional operational flexibility is unique and releases to be implemented will be defined by a desired outcome or time-period. The public will be notified of the planned releases, desired outcome, and implementation time period by the USACE's normal water management notification process (press release, internet webpage). The following sections identify the scenarios that would trigger the use of additional operational flexibility and provide details on releases to be considered under each scenario.

Additional operational flexibility will be used to address circumstances which were not evaluated in the TSP period of record, such as the following:

a. Undesirable/Prolonged High Lake Levels

Releases may be considered to prevent anticipated high lake levels or to lower high lake levels, in order to reduce risk to the HHD and to prevent additional adverse environmental impacts to Lake Okeechobee. In 2003, continuous high lake levels (above 15 ft., NGVD in excess of 13 months) resulted in a Temporary Deviation. The purpose of this Temporary Deviation was to minimize the risk of high lake levels, to lower Lake Okeechobee for prevention of additional adverse impacts in the lake and to reduce the potential of high-volume continuous releases to the estuaries. These intended purposes were accomplished while balancing other management objectives of water supply and flood control.

In the event that there are ongoing or planned activities at C&SF Project features (including CERP Projects) upstream or downstream of Lake Okeechobee, and high lake levels are projected to occur or anticipated to occur as a result of these activities and based on any combination of planned water management operations, climate forecasts, and historical information/data, then additional releases to the WCAs and to tide (estuaries) could be considered. All project purposes will be considered. When possible, the lake releases to tide (estuaries) would be limited to a pulse release from Lake Okeechobee not to exceed 2800 cfs measured at S-79 and 2000 cfs measured at the St. Lucie Estuary. This includes releases from all C&SF Project structures that discharge into the St Lucie Estuary. Releases to the WCAs would depend on available treatment capacity in the STAs and the water levels in the WCAs.

Additional releases might be implemented to lower Lake Okeechobee's level in advance of planned activities and/or to prevent high lake levels. An example is a planned muck removal

operation involving a lake drawdown in the Kissimmee River Basin that could result in the need to create storage in Lake Okeechobee prior to the planned Kissimmee River Basin drawdown.

b. Climate Conditions

In the event that climate conditions including but not limited to, El Nino, La Nina, and/or active hurricane season forecasts are projected to create or continue high lake levels, additional operational flexibility would allow releases to WCAs and to tide (estuaries) to be implemented. The lake releases to tide (estuaries) should be limited to a pulse release from Lake Okeechobee not to exceed 2800 cfs measured at S-79 and 2000 cfs measured at the St. Lucie Estuary. This includes releases from all C&SF Project structures that discharge into the St Lucie Estuary. The wet spring of 2004 (normally the dry season) and an overly active hurricane season are examples of conditions that could be addressed with additional operational flexibility.

c. Low Volume Releases

In the event that the lake level is above the Water Shortage Management Band and conditions exist that would require low-volume releases, additional operational flexibility would allow low-volume releases to be implemented. The low-volume releases would be implemented to address conditions including, but not limited to the following: to prevent and/or to lower high lake levels, to address algal blooms, to disperse saltwater in the river and/or estuary, or improve other conditions related to the Congressionally-authorized project purposes. The proposed low-volume releases would be limited to a pulse release from Lake Okeechobee of up to 2000 cfs measured at S-79 and up to 730 cfs measured at S-80.

As an example, a Low Volume Release operation occurred in 2004. Operations were conducted that included a pulse release that averaged up to 1600 cfs to the Caloosahatchee Estuary and up to 730 cfs measured at S-80. The purpose of these operations was to minimize the risk of high lake levels, to lower Lake Okeechobee for prevention of additional adverse impacts in the lake and to reduce the potential of high constant releases to the estuaries. These intended purposes were accomplished while balancing other management objectives of water supply and flood control.

Lake Okeechobee Regulation Schedule Study (LORSS)

Figures/Tables

08 February 2007

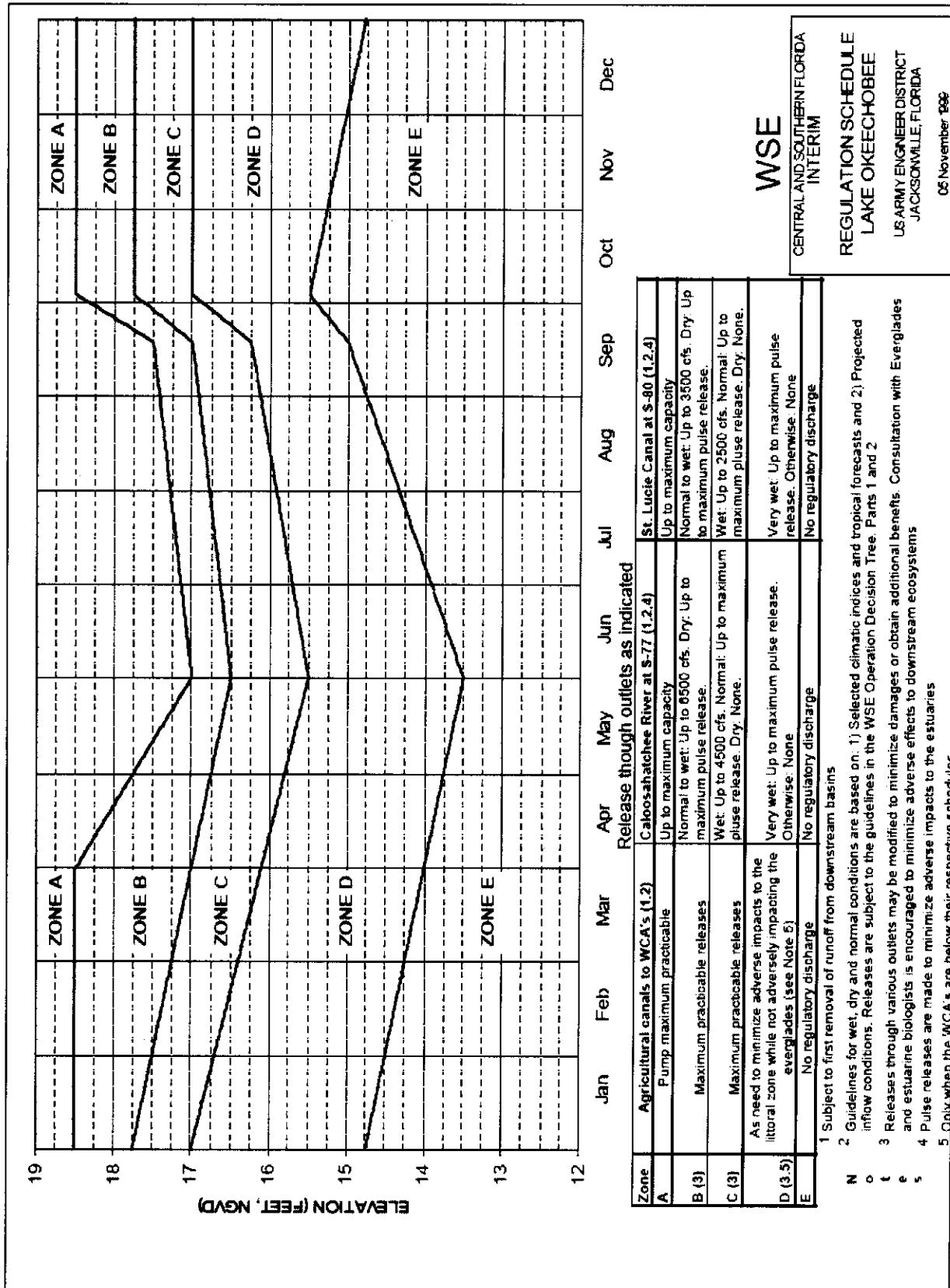


Figure 1

WSE Operational Guidelines Decision Tree

Part 1: Define Lake Okeechobee Discharges to the Water Conservation Areas

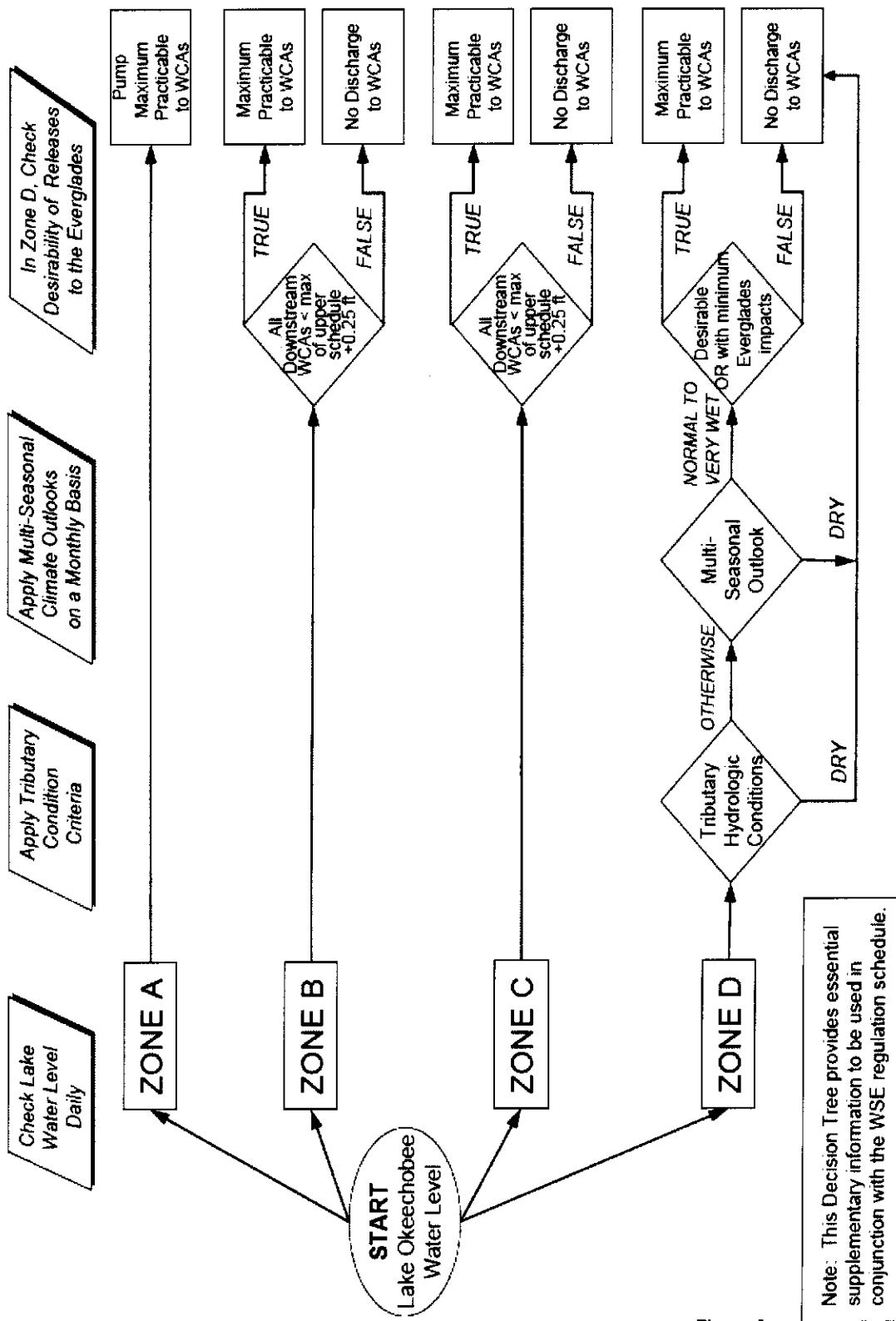


Figure 2

WSE Operational Guidelines Decision Tree

Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)

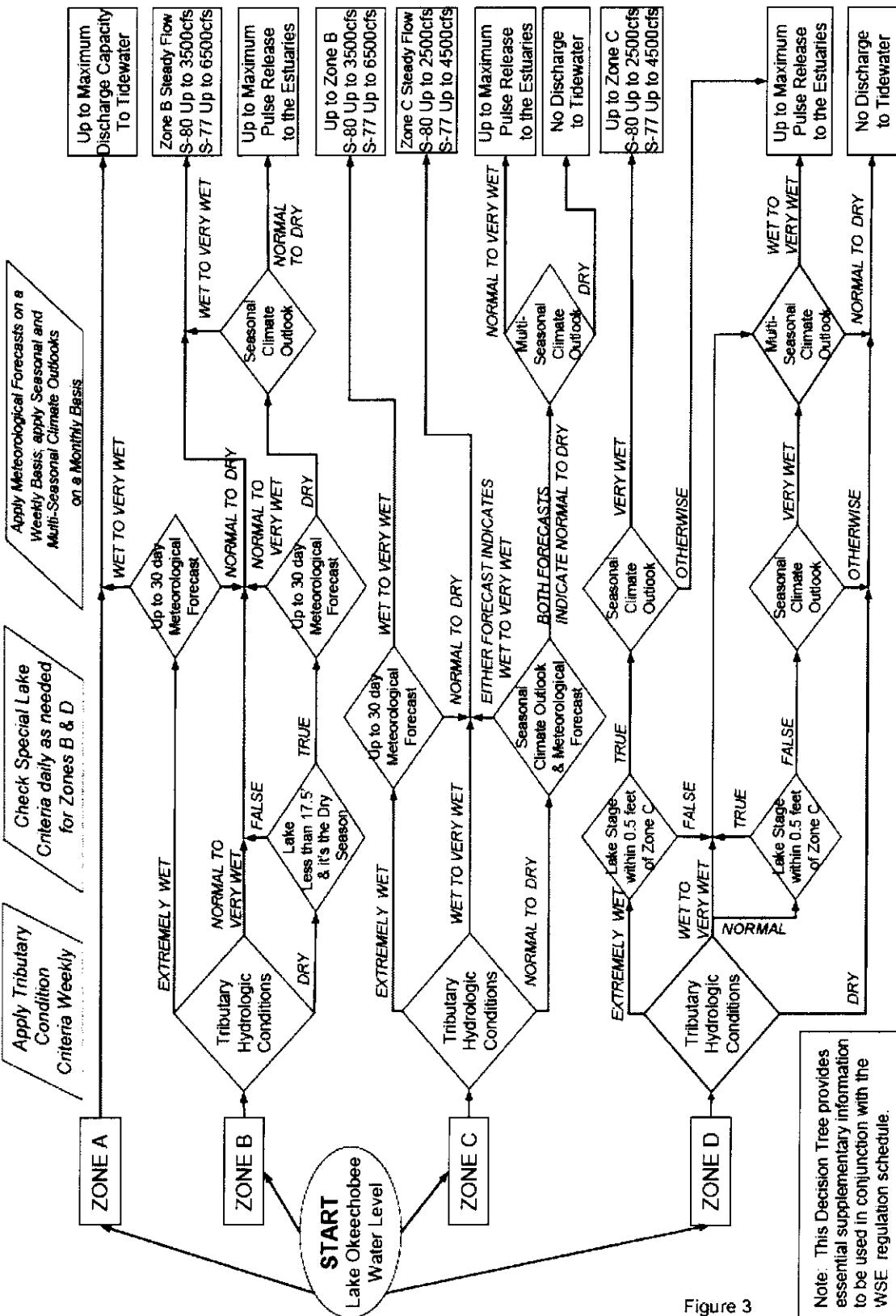
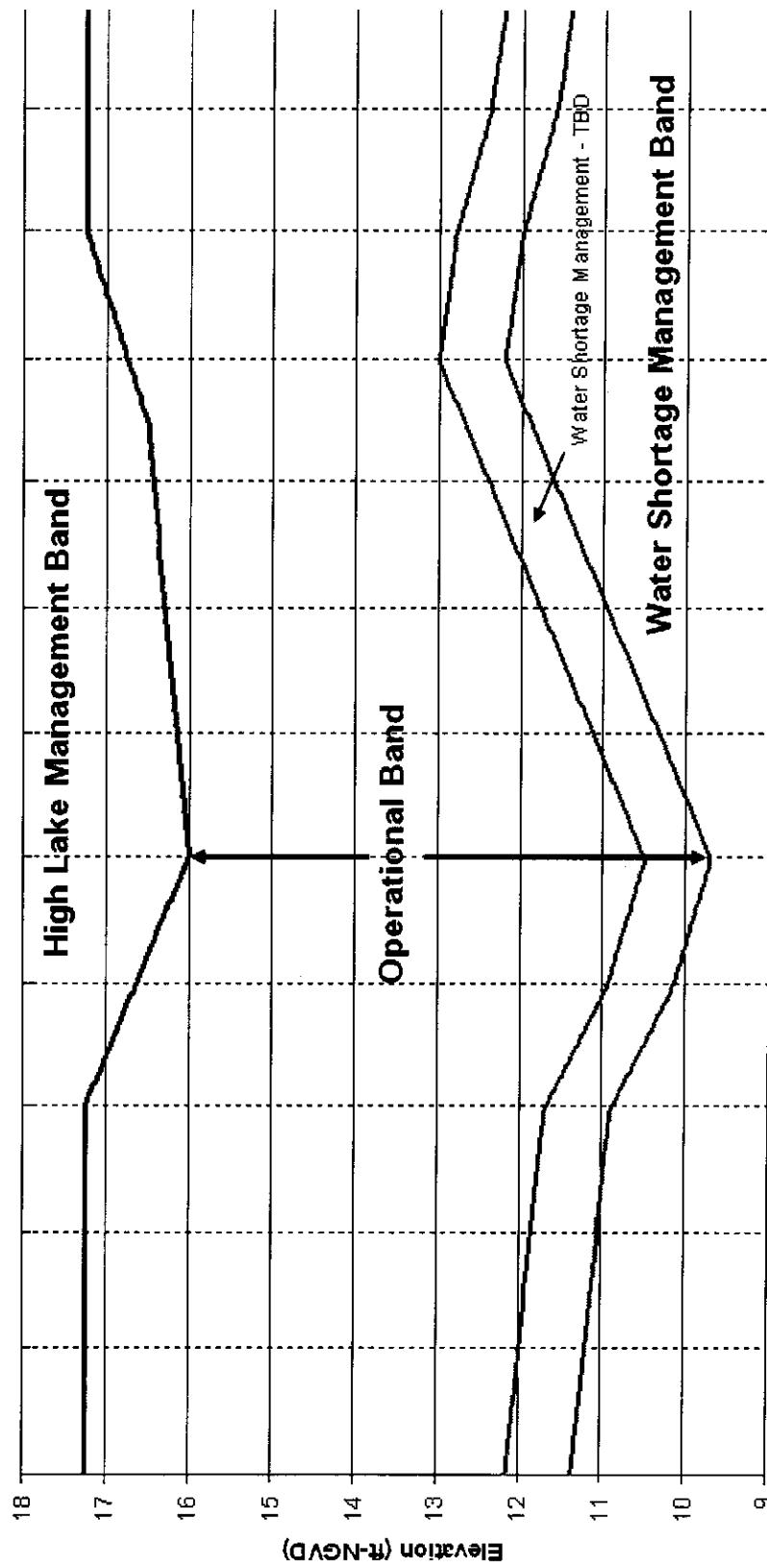


Figure 3



CENTRAL AND SOUTHERN FLORIDA PROJECT
INTERIM
LAKE OKEECHOBEE AND EVERGLADES AGRICULTURAL
AREA
Draft
**2007 LAKE OKEECHOBEE
REGULATION SCHEDULE**
PART A
DATED: 24 Oct 2007
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT

High Lake Management Band: Outlet Canals may be maintained above their optimum water management elevations.

Operational Band: Outlet Canals should be maintained within their optimum water management elevations.

Water Shortage Management Band: Outlet Canals may be maintained below optimum water management elevations. The band elevations may change upon completion of South Florida Water Management District's rule making process.

Figure 4

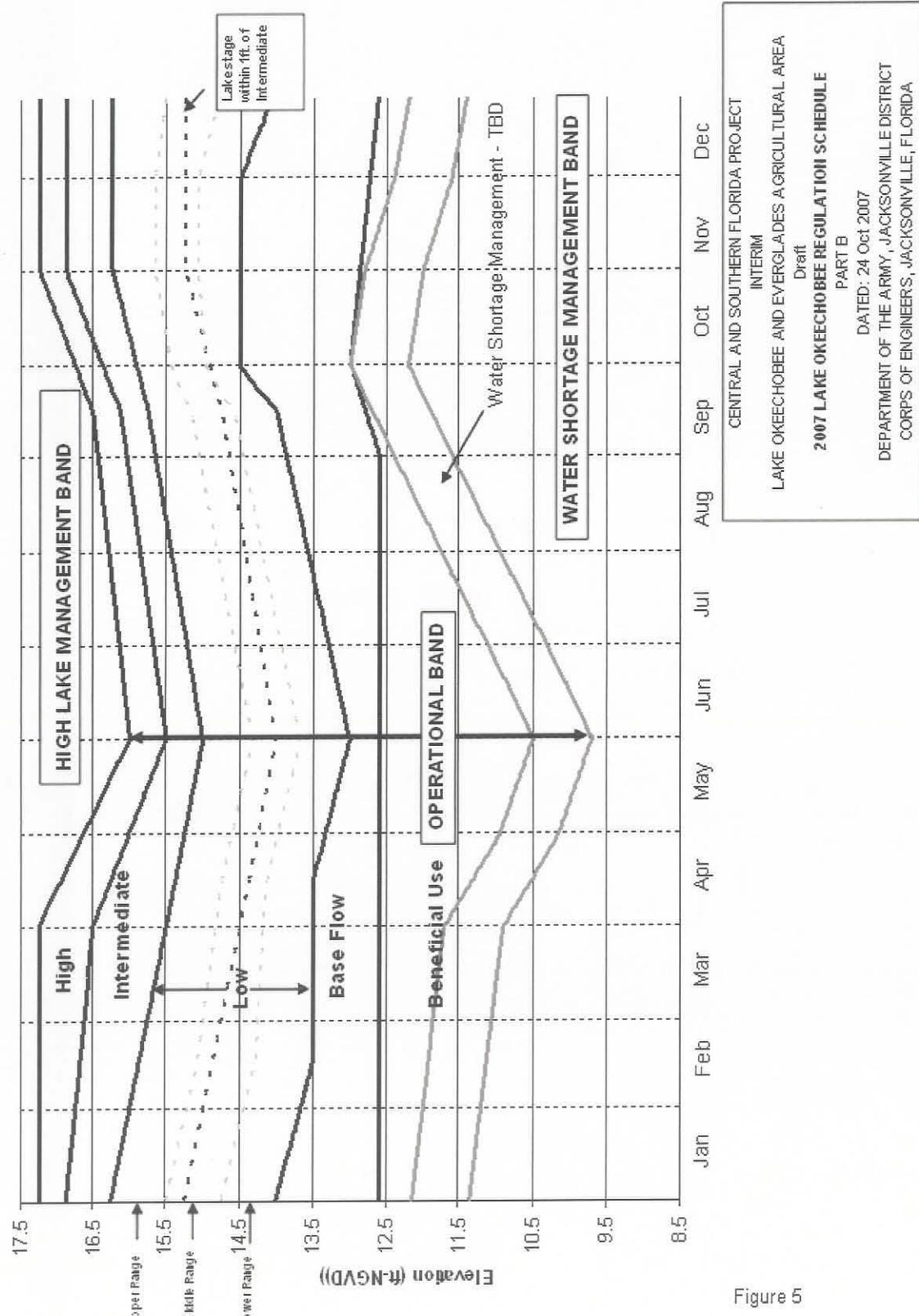


Figure 5

Lake Okeechobee Operational Guidance

Part C: Establish Allowable Lake Okeechobee Releases to the Water Conservation Areas

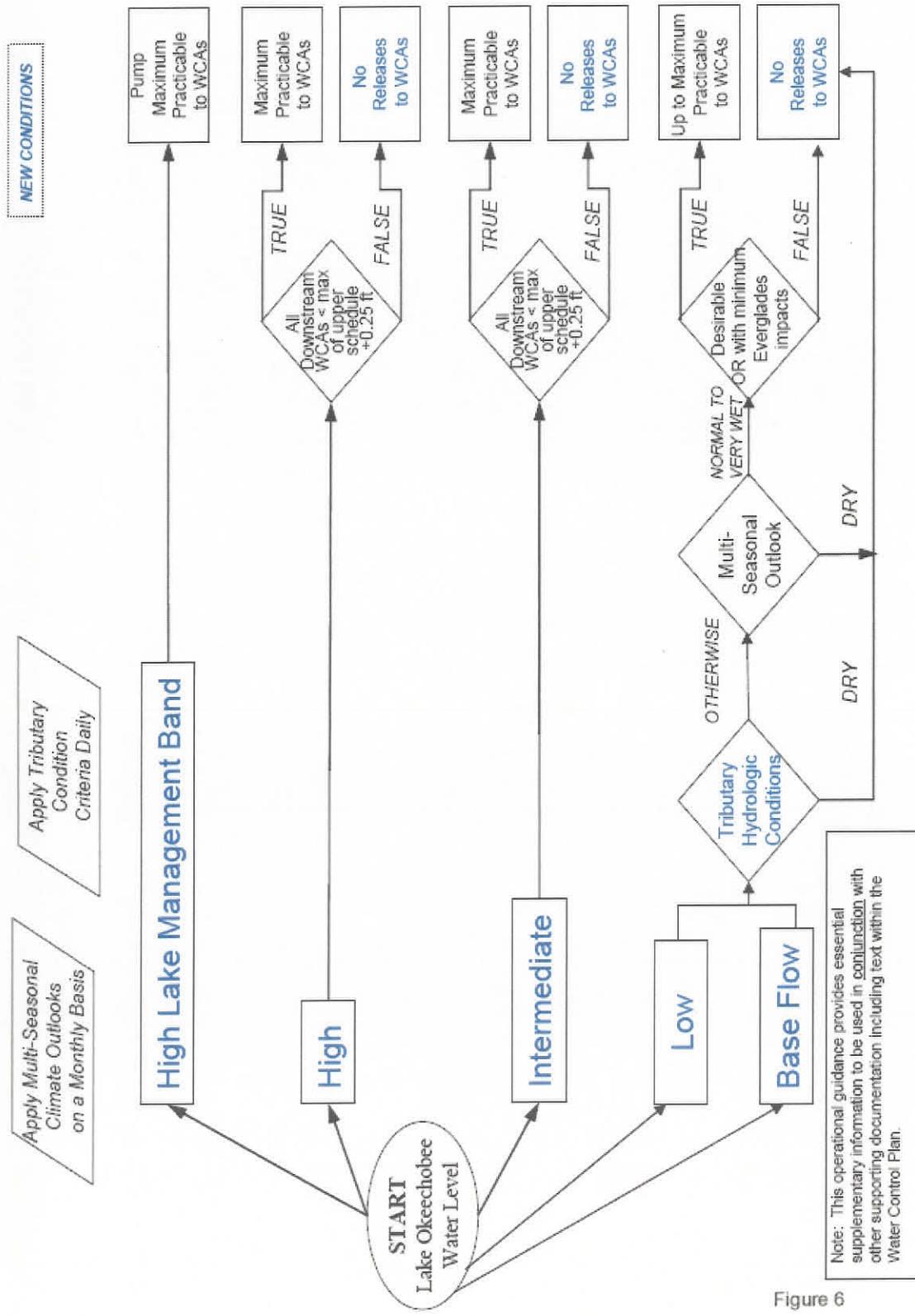


Figure 6

Note: This operational guidance provides essential supplementary information to be used in conjunction with other supporting documentation including text within the Water Control Plan.

Lake Okeechobee Operational Guidance

Part D: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)

Note: This operational guidance provides essential supplementary information to be used in conjunction with other supporting documentation including text within the Water Control Plan.

When conducting Base Flow releases, flows can be impacted West up to 650 cfs as needed to minimize impacts or provide benefits through S-80 and S-20

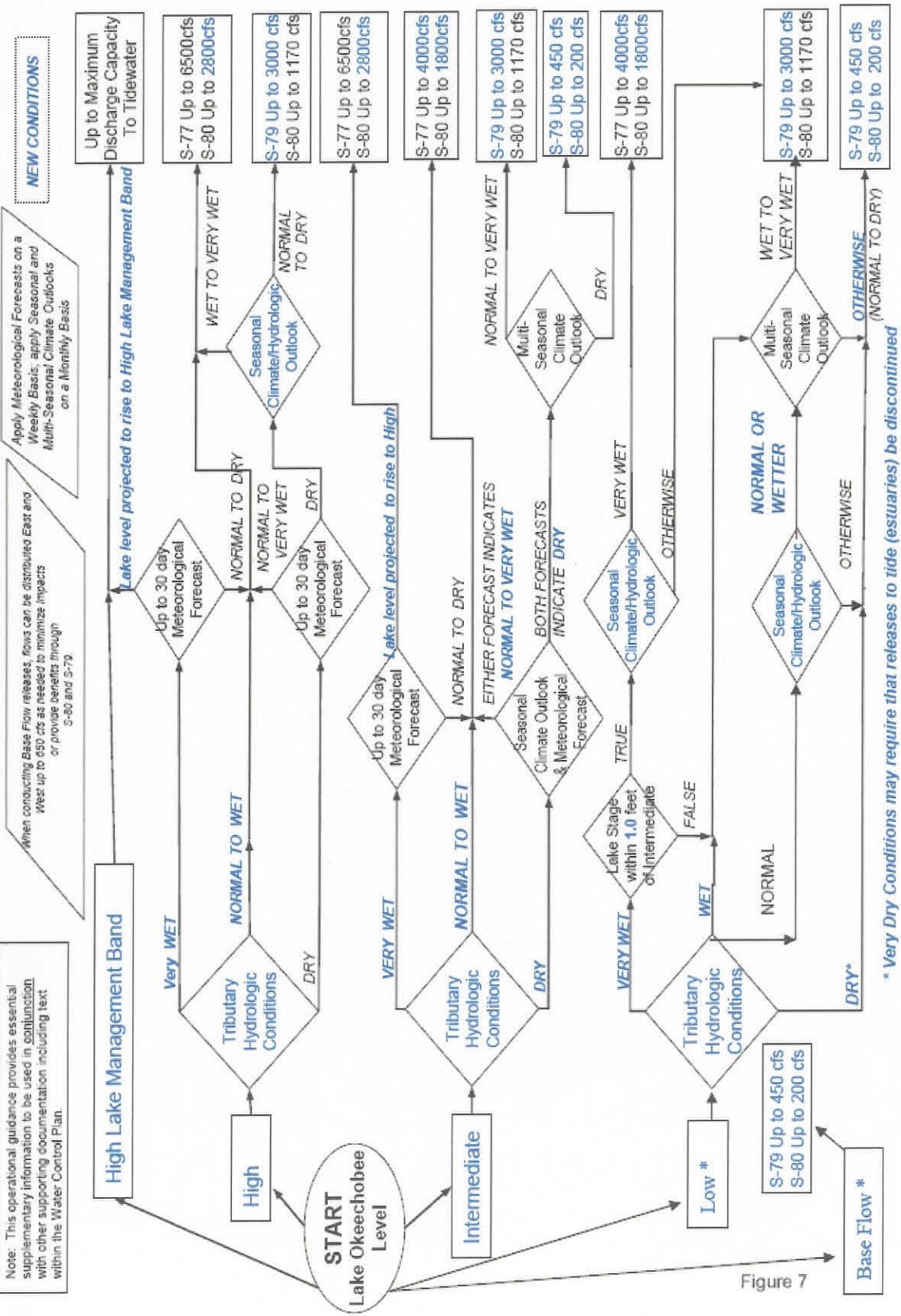


Figure 7

Table 2: Definition of Tributary conditions based on the Palmer Index and Net Inflow

Tributary Hydrologic Classification	Palmer Index Class Limits	2-wk mean L.O. Net Inflow Class Limits
Very Wet	3.0 or greater	Greater >= 6000 cfs
Wet	1.5 to 2.99	2500-5999 cfs
Near Normal	-1.49 to 1.49	500-2499 cfs
Dry	-1.5 to -2.99	-5000 – 500 cfs
Very Dry*	-3.0 or less	Less than -5000 cfs

The wettest of the two indicators describes the current tributary condition

*For modeling purposes, the dry and very dry classes can be combined into one class

The Net Inflow is represented by $NI = RF - ET + \text{Inflows}$,
where $RF = \text{rainfall over the lake}$, $ET = \text{lake evapotranspiration}$, and $\text{Inflows} = \text{all inflows to the Lake}$.

Using the basic mass balance equation, the Net Inflow can be calculated by $NI = DS + \text{Outflows}$,
where $DS = \text{storage change}$, and $\text{Outflows} = \text{measured outflows}$

The Palmer Index is a meteorological index that responds to weather conditions that have been abnormally dry or abnormally wet. The index is calculated based on precipitation and temperature data, as well as the local available water content of the soil.

Discussion on Palmer Index: <http://www.drought.unl.edu/whatis/indices.htm#psi>
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/palmer_drought/wpdanote.shtml

Current Conditions:
http://www.noaa.gov/analysis_monitoring/regional_monitoring/palmer.cgi

Table 2

APPENDIX B

Coastal Zone Management Consistency For The Lake Okeechobee Regulation Schedule Study

**U.S. Army Corps of Engineers
Jacksonville District**

November 2007

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FLORIDA COASTAL ZONE MANAGEMENT PROGRAM FEDERAL CONSISTENCY EVALUATION PROCEDURES

Lake Okeechobee Regulation Schedule Lake Okeechobee Florida

1. Chapter 161, Beach and Shore Preservation. The intent of the coastal construction permit program established by this chapter is to regulate construction projects located seaward of the line of mean high water and which might have an effect on natural shoreline processes.

Response: The proposed work project is not seaward of the mean high water line and would not affect shorelines or shoreline processes.

2. Chapters 163(part II), 186, and 187, County, Municipal, State and Regional Planning. These chapters establish the Local Comprehensive Plans, the Strategic Regional Policy Plans, and the State Comprehensive Plan (SCP). The SCP sets goals that articulate a strategic vision of the State's future. Its purpose is to define in a broad sense, goals, and policies that provide decision-makers directions for the future and provide long-range guidance for an orderly social, economic and physical growth.

Response: The proposed action has been coordinated with various Federal, State and local agencies during the planning process. The Supplemental Environmental Impact Statement (SEIS) will be coordinated with the State to determine final compliance.

3. Chapter 252, Disaster Preparation, Response and Mitigation. This chapter creates a state emergency management agency, with the authority to provide for the common defense; to protect the public peace, health and safety; and to preserve the lives and property of the people of Florida.

Response: The proposed action would have no adverse effect on existing or projected future flood control, or public safety. Adequate flood control for residents of the region will be maintained. This action would be consistent with the efforts of Division of Emergency Management.

4. Chapter 253, State Lands. This chapter governs the management of submerged state lands and resources within state lands. This includes archeological and historical resources; water resources; fish and wildlife resources; beaches and dunes; submerged grass beds and other benthic communities; swamps, marshes and other wetlands; mineral resources; unique natural features; submerged lands; spoil islands; and artificial reefs.

Response: The proposed regulation schedule, referred to as Alternative E (T-3) has demonstrated distinct ecological benefits for Lake Okeechobee's littoral zone and

marsh and some positive benefits for the St. Lucie and Caloosahatchee estuaries, including benthic communities and seagrasses.

5. Chapters 253, 259, 260, and 375, Land Acquisition. This chapter authorizes the State to acquire land to protect environmentally sensitive areas.

Response: *The proposed action is completely operational and no structural features, construction, modification of existing structures, or land acquisition is being proposed. Therefore, this action is in compliance with this chapter.*

6. Chapter 258, State Parks and Aquatic Preserves. This chapter authorizes the State to manage state parks and preserves. Consistency with this statute would include consideration of projects that would directly or indirectly adversely impact park property, natural resources, park programs, management or operations.

Response: *Due to the nature of the proposed action, state parks or aquatic preserves within the immediate vicinity of the project would not be affected. The project is consistent with this chapter.*

7. Chapter 267, Historic Preservation. This chapter establishes the procedures for implementing the Florida Historic Resources Act responsibilities.

Response: *This project has been coordinated with the State Historic Preservation Officer (SHPO). No historic properties would be affected by this action. The project is consistent with the goals of this chapter.*

8. Chapter 288, Economic Development and Tourism. This chapter directs the State to provide guidance and promotion of beneficial development through encouraging economic diversification and promoting tourism.

Response: *Contribution from the study area to the State's tourism economy would not be compromised by this action. The action would be compatible with tourism for this area and could potentially contribute to overall growth, development and sustainability of the area through greater protection and enhancement of key natural resources, including freshwater and estuarine fisheries and wildlife. Therefore the proposed action would be consistent with the goals of this chapter.*

9. Chapters 334 and 339, Transportation. This chapter authorizes the planning and development of a safe balanced and efficient transportation system.

Response: *No public transportation systems would be impacted by this project.*

10. Chapter 370, Saltwater Living Resources. This chapter directs the State to preserve, manage and protect the marine, crustacean, shell and anadromous fishery resources in State waters; to protect and enhance the marine and estuarine environment; to regulate fishermen and vessels of the state engaged in the taking of such resources within or without State waters; to

issue licenses for the taking and processing products of fisheries; to secure and maintain statistical records of the catch of each such species; and to conduct scientific, economic, and other studies and research.

Response: Effects to the northern estuaries were determined by freshwater discharges from Lake Okeechobee. Compared to the No Action Alternative, the estuaries overall will have improved flow regimes. The estuarine biota is expected to benefit from implementation of the proposed water regulation schedule. The objective of the Lake Okeechobee Regulation Schedule Study and selection of a Preferred Alternative was to reduce high freshwater flows, especially during critical spawning season. Additionally, the Preferred Alternative substantially increases flows in the preferred range for the Caloosahatchee and St. Lucie estuaries. The proposed action is in compliance with this chapter.

11. Chapter 372, Living Land and Freshwater Resources. This chapter establishes the Game and Freshwater Fish Commission and directs it to manage freshwater aquatic life and wild animal life and their habitat to perpetuate a diversity of species with densities and distributions which provide sustained ecological, recreational, scientific, educational, aesthetic, and economic benefits.

Response: The proposed action will be coordinated with the Florida Fish and Wildlife Conservation Commission during coordination of the revised draft SEIS.

12. Chapter 373, Water Resources. This chapter provides the authority to regulate the withdrawal, diversion, storage, and consumption of water.

Response: This action is an operations only adjustment of existing protocols for managing Lake Okeechobee water levels, and regulatory discharges downstream as they are currently conducted.

13. Chapter 376, Pollutant Spill Prevention and Control. This chapter regulates the transfer, storage, and transportation of pollutants and the cleanup of pollutant discharges.

Response: This action does not involve transfer, storage, or transportation of pollutants.

14. Chapter 377, Oil and Gas Exploration and Production. This chapter authorizes the regulation of all phases of exploration, drilling, and production of oil, gas, and other petroleum products.

Response: This action does not involve the exploration, drilling or production of gas, oil or petroleum product and therefore, this chapter does not apply.

15. Chapter 380, Environmental Land and Water Management. This chapter establishes criteria and procedures to assure that local land development decisions consider the regional impact nature of proposed large-scale development. This chapter also deals with the Area of Critical State Concern program and the Coastal Infrastructure Policy.

Response: The proposed action would not have any regional impact on resources in the area. Therefore, the project is consistent with the goals of this chapter.

16. Chapters 381 (selected subsections on on-site sewage treatment and disposal systems) and 388 (Mosquito/Arthropod Control). Chapter 388 provides for a comprehensive approach for abatement or suppression of mosquitoes and other pest arthropods within the state.

Response: The proposed action would not further the propagation of mosquitoes or other pest arthropods.

17. Chapter 403, Environmental Control. This chapter authorizes the regulation of pollution of the air and waters of the State by the Florida Department of Environmental Regulation (now a part of the Florida Department of Environmental Protection).

Response: A revised draft SEIS addressing project impacts has been prepared and will be reviewed by the appropriate resource agencies including the Florida Department of Environmental Protection. Based on this action, there will be no lasting adverse effects on water quality, air quality, or other environmental resources.

18. Chapter 582, Soil and Water Conservation. This chapter establishes policy for the conservation of the state soil and water through the Department of Agriculture. Land use policies will be evaluated in terms of their tendency to cause or contribute to soil erosion or to conserve, develop, and utilize soil and water resources both onsite or in adjoining properties affected by the project. Particular attention will be given to projects on or near agricultural lands.

Response: As described in greater detail in the revised draft SEIS, no significant adverse impact to existing water supply or flood control for agricultural lands within the project region are expected. The action is completely operational in nature and does not involve the disturbance of surface or sub-surface soils in any way.

APPENDIX C

Final Biological Opinion and Final Fish and Wildlife Coordination Act Report

**U.S. Army Corps of Engineers
Jacksonville District**

November 2007

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960



October 15, 2007

Colonel Paul L. Grosskruger
District Commander
U.S. Army Corps of Engineers
701 San Marco Boulevard, Room 372
Jacksonville, Florida 32207-8175

Service Consultation Code: 41420-2006-F-0072

Formal Consultation Initiation Date: July 3, 2006

Applicant: U.S. Army Corps of Engineers

Project: Lake Okeechobee Regulation

Schedule Study

Dear Colonel Grosskruger:

This is the Fish and Wildlife Service's (Service) biological opinion, based on our review of the U.S. Army Corps of Engineers' (Corps) proposed revision of the Lake Okeechobee regulation schedule (LORS), and its effects on the Everglade snail kite (*Rostrhamus sociabilis plumbeus*) in accordance with section 7 of the Endangered Species Act of 1973, as amended (Act) (16 U.S. Code [U.S.C.] 1531 *et seq.*). A complete administrative record of this consultation is on file in the South Florida Ecological Services Office, Vero Beach, Florida.

This project consists of operational changes to the water management infrastructure that discharges water from Lake Okeechobee to downstream systems (St. Lucie and Caloosahatchee estuaries, the Everglades Agricultural Area [EAA] and the Water Conservation Areas [WCAs]). The proposed changes are operational only and no new construction is planned. The revised schedule is intended to be active for three years, until around 2010 when the following schedule will incorporate possible structural improvements along with benefits from initial components of the Comprehensive Everglades Restoration Plan (CERP).

The proposed water regulation schedule will replace the current Water Supply and Environment (WSE) regulation schedule. The tentatively selected plan (TSP), known as Alternative E, was identified by the Corps to be the alternative that met the goal of preserving the integrity of the Herbert Hoover Dike while balancing other objectives of the study. The other study objectives include water supply, navigation, recreation, fish and wildlife enhancement in the littoral zone of Lake Okeechobee, and reducing high regulatory releases to the St. Lucie and Caloosahatchee Estuaries.

Acronyms and abbreviations used in this biological opinion are outlined in Table 1.



Table 1. Acronyms and abbreviations used in this biological opinion on the LORS.

Acronym/ Abbreviation	Definition
Act	Endangered Species Act of 1973, as amended (87 Stat. 884; 16 U.S.C. 1531 <i>et seq.</i>)
BA	Biological Assessment
C&SF	Central and Southern Florida
CERP	Comprehensive Everglades Restoration Plan
cfs	cubic feet per second
CLA	Class Limit Adjustments (modification to WSE)
Corps	U.S. Army Corps of Engineers
District	South Florida Water Management District
EA	Environmental Assessment
EAA	Everglades Agricultural Area
EIS	Environmental Impact Statement
ENP	Everglades National Park
ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
FWCA	Fish and Wildlife Coordination Act
IOP	Interim Operating Plan
LORS	Lake Okeechobee Regulation Schedule
LORSS	Lake Okeechobee Regulation Schedule Study
MFL	Minimum Flows and Levels
MSRP	South Florida Multi-Species Recovery Plan
NGVD	National Geodetic Vertical Datum
PAL	Planning Aid Letter
PDT	Project Delivery Team
POR	Period of Record
ppb	parts per billion
SD	Standard Deviation
SEIS	Supplemental Environmental Impact Statement
Service	Fish and Wildlife Service
TSP	Tentatively Selected Plan (in this case, Alternative E, previously known as Alternative T3)
WCA(s)	Water Conservation Area(s)
WSE	Water Supply and Environment (the regulation schedule from 2000 to present)

This biological opinion is based on information provided in the Corps' Biological Assessment (received July 3, 2006), weekly Project Delivery Team (PDT) meetings, analysis of modeling output, and additional information. The Corps provided a determination of "no effect" to the eastern indigo snake (*Drymarchon corais couperi*), bald eagle (*Haliaeetus leucocephalus*), Cape Sable seaside sparrow (*Ammmodramus maritimus mirabilis*) and West Indian manatee (*Trichechus manatus*). The Service concurs with this determination for the indigo snake, the bald eagle and the Cape Sable seaside sparrow. The Corps also provided a determination of "may affect" with beneficial effects for the wood stork (*Mycteria americana*), Okeechobee gourd (*Cucurbita*

okeechobeensis) and Everglade snail kite. The Service concurs with the Corps' determination that the project "may affect, but is not likely to adversely affect" the wood stork and Okeechobee gourd, but does not concur with this determination for the Everglade snail kite. The Service has also determined that the project "may affect, but is not likely to adversely affect" the West Indian manatee.

Okeechobee Gourd, Wood Stork and West Indian Manatee

Okeechobee Gourd

The Okeechobee gourd is an annual or perennial vine endemic to Florida, known to occur in natural and man-made islands in Lake Okeechobee. The seeds germinate in early spring during the dry season. Seedlings do not tolerate water-soaked soil for extended periods, and by the rainy season, the vines will have climbed shrubs, avoiding complete inundation as water levels rise. The 2004-2005 hurricanes impacted the gourd population in Lake Okeechobee. High winds and surging water disrupted most of the known gourd communities in the lake, and sustained high water levels throughout 2005 did not favor their recolonization. In 2006, water levels dropped significantly due to low rainfall throughout the year, and the gourd has reappeared in several areas. The proposed project will lower the lake an average of 1.0 to 1.5 feet (ft), which is expected to expose more growing substrate for longer periods, and will likely benefit the gourd. The Service concurs that the proposed action may affect, but is not likely to adversely affect, the Okeechobee gourd.

Wood Stork

The United States breeding population of the wood stork was listed under the Act as endangered on February 28, 1984 (Service 1984). No critical habitat has been designated for the wood stork; therefore, none will be affected.

Breeding colonies of wood storks are documented in all southern Florida counties except for Okeechobee County. The littoral zone of Lake Okeechobee is an important foraging area for storks that breed in the region. Suitable stork foraging habitat must provide both a sufficient density and biomass of forage fish and other prey, and have vegetation characteristics that allow storks to locate and capture prey. Wood storks feed almost entirely on fish between 1 to 10 inches in length (Kahl 1964; Ogden et al. 1976; Coulter 1987) but may occasionally consume crustaceans, amphibians, reptiles, mammals, birds, and arthropods. Unlike the apple snail (*Pomacea paludosa*), which is the primary prey of snail kites, most of the prey animals that wood storks feed upon are mobile and can recolonize flooded areas relatively soon following drought. Consequently, extreme water stages from year to year within the littoral zone do not have the same negative affect on storks as they do on snail kites. Fish are able to move to follow rising or receding water, and can quickly relocate in response to inter- and intra-annual changes in water levels.

The most important feature of Lake Okeechobee's littoral zone foraging habitat is a consistent and gradual lowering of the water elevation during the dry season (Smith et al. 1995). This spring recession serves to concentrate prey in isolated pools and shallow areas, making it more available as forage for wood storks and other wading birds. The Service analyzed the simulated

annual hydrographs for the selected alternative, compared it to the base run alternative, and specifically looked for trends in the spring recession window. We found that the proposed project would produce slightly more years of gradual recession across suitable elevations of the littoral zone during the dry season than did the base run. Whether or not this slight increase was a significant change for the better is debatable, but it did indicate the potential for a slight improvement of conditions for the wood stork within the lake. The Service concurs that the proposed action may affect, but is not likely to adversely affect, the wood stork.

West Indian Manatee

The West Indian manatee is listed as an endangered species under the Act (16 U.S.C. 1531 *et seq.*) (32 FR 4001) and is further protected as a depleted subpopulation under the Marine Mammal Protection Act (16 U.S.C. 1361-1407). Critical habitat for the Florida subspecies (*Trichechus manatus latirostris*) was designated in 1976 [50 Code of Federal Regulations [CFR] §17.95(a)]. No specific primary or secondary constituent elements were included in the critical habitat designation. However, experts agree essential habitat features for the manatee include seagrasses for foraging, shallow areas for resting and calving, channels for travel and migration, warmwater refuges during cold weather, and fresh water for drinking (Service 2001). Designated critical habitat within the areas to be affected by this project includes portions of the Caloosahatchee River and all coastal waters in Lee County, portions of the St. Lucie estuary, and the Indian River Lagoon.

There is no documentation or evidence that manatees are adversely affected by changes in water quality. The two most significant threats to the Florida manatee population statewide are collisions with watercraft and the loss of warm water habitat (Runge et al. 2007). Other threats, which are relatively minor in comparison, include crushing or entrapment in gates and locks, entanglement in ropes, lines, and nets, ingestion of fishing gear or debris, vandalism, poaching, and exposure to red tide brevetoxin (Bossart et al. 1998).

There is no direct link between upland run-off and red tide events. Run-off from sources in the Caloosahatchee River basin has been examined since 1947, and while there may be a potential connection, researchers have been unable to establish a direct link with upland run-off and red tide blooms. It appears that for such blooms to occur, the dinoflagellates need multiple sources of nutrients (Heil 2005).

This project has the potential to directly affect water quality within the St. Lucie and Caloosahatchee Rivers, and indirectly, the extent and health of seagrass resources within these systems. Manatees occur year-round in Lake Okeechobee and throughout the Central and Southern Florida (C&SF) as well as the Caloosahatchee River and other estuarine waters in Lee County. The Service knows of no instance or recorded event where a manatee was adversely affected by degraded water quality in these or any other areas.

Although the distribution and abundance of seagrass beds and other submerged vegetation could influence the movements of manatees, the Service does not consider the availability of forage to be a limiting factor for the population as a whole, throughout its habitat in Florida. The latest science indicates that with over 1 million acres of low density seagrasses in Florida, over

73,000 manatees could be supported by this amount of potential forage. The current manatee population is estimated to be around 3,000 animals, which indicates that manatee populations in Florida are not food-limited, and that potential effects to seagrasses within the project area are not likely to adversely affect manatees (Smith 2005).

Regarding potential adverse modification of critical habitat, the current science on manatees indicates that their population is at a higher level now than it was several decades ago (Haubold et al. 2006). No primary constituent elements have been described within the critical habitat. During plan formulation, the Service remained concerned about the potential effects of a revised LORS on the abundance and distribution of seagrass beds in the Caloosahatchee and St. Lucie estuaries. However, the modeling of the selected alternative indicates that it is likely to be no worse than the future without project condition with respect to salinity conditions in the estuaries. Modeling suggests that the new regulation schedule will slightly improve the period of time when minimum flows will be provided to the upper portions of the Caloosahatchee River; these flows sustain other beds of submerged aquatic vegetation dominated by the freshwater grass *Vallisneria* (commonly known as tape grass or eel grass), which are available as foraging areas for manatees. For a more detailed description of these resources and the anticipated effects, please refer to our Draft and Final Fish and Wildlife Coordination Act reports (Service 2007a, 2007b). Based on this, we believe that the proposed regulation schedule will not destroy or adversely modify critical habitat, relative to the future without project condition.

While the Corps provided a determination of “no effect” on the West Indian manatee, the Service believes that the more appropriate determination is that the proposed action may affect, but is not likely to adversely affect, the West Indian manatee or its critical habitat.

Consultation History

The Service has a long history of reviewing and providing recommendations to the Corps on the effects of water regulation in Lake Okeechobee. Formal consultation last occurred in 1978, when the Service provided a biological opinion finding that implementation of the regulation schedule proposed at that time would not jeopardize the endangered Everglade snail kite.

The 1978 formal consultation was followed by 20 years of informal endangered species consultations and advisement. The Service provided several Planning Aid Letters (PALs) and Fish and Wildlife Coordination Act (FWCA) reports to the Corps addressing various modifications to the regulation schedule, all of which we considered improvements to an otherwise flawed system of water management. The Service generally supported the changes to the schedule, sometimes after extended periods of analysis and plan development, and at other times involving either modifications or temporary deviations requested by the Corps in response to particular circumstances.

It is important to note that Service policy on the format and content of Incidental Take Statements was not in effect at the time of the 1978 formal consultation; these provisions arose from the amendments to the Act of 1982. The final regulations governing incidental take statements were published in the *Federal Register* on June 3, 1986. This current consultation

continues our practice of reviewing each proposed revision of the regulation schedule as an independent project, rather than a single, long-term action. This is the first biological opinion on the LORS that includes part of an Incidental Take Statement.

The following chronology includes only the major milestones from 1978 to the present. Many additional meetings and correspondence of lesser importance are not included in this list.

On March 8, 1978, the Service issued a biological opinion on the Corps' proposal to raise the Lake Okeechobee regulation schedule from the 14.5 - 16.0 ft schedule to the 15.5 - 17.5 ft, 1978 schedule (all elevation measurements in this report are expressed in National Geodetic Vertical Datum [NGVD]). The biological opinion considered the effects of the project to the Everglade snail kite, and concluded that the action was not likely to jeopardize the continued existence of this species. However, the Service also expressed concern that it was difficult to predict the exact response of apple snail populations to the new regulation schedule, and we recommended that the Corps initiate an apple snail monitoring program in the lake's littoral zone, which was designated as critical habitat for the snail kite in 1977 (Service 1977).

On June 19, 1978, the Service provided a FWCA report in response to the proposed 1978 schedule. The Service did not oppose implementation of the 1978 schedule, but recommended monitoring of apple snails, the vegetative composition in the littoral zone, the fisheries in the marsh, and bird rookeries and other breeding areas. The Service also recommended management of water levels within the levees at Torry, Kreamer, and Ritta Islands in the southeastern portion of the lake to create additional marsh habitat.

On September 5, 1985, the Service provided a PAL to the Corps on the potential adverse environmental effects of raising the lake's regulation schedule from the 15.5 - 17.5 ft schedule, then in effect, to a 19.5 - 21.5 ft schedule, as part of an effort to increase water supply in south Florida. The PAL cited evidence suggesting that the 1978 schedule, which had been in effect for nearly six years, was causing adverse effects on the littoral marsh and its associated fish and wildlife resources. We recommended long-term monitoring of the effects of the 1978 schedule, and recommended against the 19.5 to 21.5 ft schedule, which we predicted would eliminate about 55,600 acres of littoral wetlands, including willow-vegetated bars used by wading birds and the snail kite for nesting. The PAL also noted that the Corps had not carried out the Service's 1978 recommendation to partially compensate for adverse effects caused by the 1978 schedule through restoration of marshes at Torry, Kreamer, and Ritta Islands.

On June 10, 1987, the Service sent a letter to the South Florida Water Management District (District), requesting re-evaluation of the 1978 schedule, based on the observed stress on the vegetation in the littoral zone.

In 1988, the Lake Okeechobee Littoral Zone Technical Group, a group of wetland and wildlife scientists (including the Service), recommended adoption of a lower lake regulation schedule, known as Run 22.

In 1992, a schedule known as Run 25 was implemented for a two-year trial period, instead of the recommended Run 22.

On March 18, 1993, the Corps, responding to a request from the District, called for comments on the Run 22 schedule.

On May 14, 1993, the Service sent a letter to the Corps stating that Run 22 or a similar schedule would apparently be preferable to the Run 25 schedule for protection of the littoral zone. The letter requested that the Service and the Corps develop a Scope of Work to prepare a draft FWCA report on Run 22. Although our files contain a draft Scope of Work, we believe this was never finalized and that the Service never prepared an FWCA report evaluating Run 22.

In May 1994, the Corps held two public hearings on the continued use of Run 25 as the lake's regulation schedule. One of the alternatives considered in that review was Run 22AZE, a modification of Run 22. Following the public hearings, the Corps extended the use of Run 25.

The original effort using the title Lake Okeechobee Regulation Schedule Study (LORSS) began with a June 14, 1995, public notice requesting comment on the alternatives that were then under consideration.

The Corps, through a contract with Lotspeich and Associates, conducted eight week-long sampling efforts in the lake's littoral zone between May 1997 and November 1998. This provided baseline data on vegetation and general observations of fish and wildlife prior to plan formulation for the LORSS. The study did not include sampling for apple snails and only recorded observations of snail kites in general avifauna surveys. The final report was issued in June 1999, after the Corps had selected a preferred alternative under the LORSS.

On September 24, 1997, the Florida Game and Fresh Water Fish Commission (now the Florida Fish and Wildlife Conservation Commission, or FWC) and the Service jointly sent a PAL to the Corps, which noted that the FWC and the Service preferred Run 22AZE overall among the alternatives then under consideration.

On April 15, 1998, the District presented preliminary results of simulations of a newly devised alternative, named WSE. Lacking adequate time to evaluate fully the newly introduced WSE alternative, both the FWC and the Service stated to the Governing Board that Run 22AZE remained their preferred alternative.

On September 23, 1998, the Service provided a PAL in response to discussions at a meeting on September 11, 1998, involving development of an implementation strategy for the WSE schedule.

On February 18, 1999, the Corps officially notified the Service that the WSE schedule would be the preferred alternative in the Draft Environmental Impact Statement (EIS) for the LORSS. That letter also stated the Corps' determination that the WSE schedule was not likely to adversely affect federally listed threatened or endangered species.

In July 1999, the Service received a copy of the Draft EIS for the LORSS. The draft FWCA report had not been completed prior to issuance of the Draft EIS.

On July 30, 1999, the Service issued the draft FWCA report on the LORSS. This report concurred with the Corps' determination that implementation of the WSE water regulation schedule was not likely to adversely affect federally listed threatened or endangered species or result in destruction or adverse modification of designated critical habitat. Modeling simulations predicted that WSE would show slight improvement by reducing damaging high water levels relative to the previous Run 25 schedule. Because no formal consultation was conducted, and no biological opinion was issued, the Service did not provide the Corps with an estimation of the remaining level of incidental take that would be expected in implementing the WSE schedule.

On October 6, 1999, the Service issued the final FWCA report on the LORSS. The Service recommended that the Corps refine their climate forecasting methodology, conduct studies to quantify the effects of lake levels on various flora and fauna, and conduct research on lake phosphorus levels. We also reiterated our previous recommendations to mitigate adverse effects caused by the 1978 schedule through restoration of marshes at Torry, Kreamer, and Ritta Islands.

After several years of above average rainfall and sustained high water levels, the FWC requested by letter on March 27, 2000, that the Corps investigate a managed recession of lake levels. The District Governing Board approved the Shared Adversity Plan in April 2000, with the goal of lowering Lake Okeechobee from 14.89 to 13 feet NGVD, and holding it at 13 feet NGVD for 8 weeks to promote the reestablishment of submerged aquatic vegetation and thereby benefit fish and wildlife. The Service supported this plan and praised the Governing Board for assuming risks to benefit the lake's ecology. The plan largely accomplished its intended ecological benefits despite two less than desirable characteristics. First, climate predictions proved to be incorrect, and rainfall was not available to hold the lake at 13 ft. Lake stage dropped to a record low around 9 ft in May 2001, and the lake stage rose abruptly (good for water supply, but perhaps too fast for maximal ecological benefit) following late wet season rains. Due to water supply concerns, the District allowed backpumping of water from the EAA to the lake and temporary forward pumps that allowed delivery of water to the EAA below stages that could be accommodated by the permanent structures on the south side of the lake. Although the initial rate of rise in water levels following the drought was considered too rapid by some ecologists, the lake stage did not rise to damaging levels. This allowed an extensive regrowth of submerged aquatic vegetation the following spring under excellent water clarity conditions.

The Adaptive Protocols for Lake Okeechobee Operations were accepted by resolution of the Governing Board of the District on January 9, 2003. The Adaptive Protocols provided additional guidance on the consultative process that water mangers in the District used to decide specific water release volumes within the range of operations allowed under WSE.

On December 8, 2003, the Corps asked the Service to review a temporary deviation from the WSE schedule that would allow Level I Pulse Releases to the St. Lucie and Caloosahatchee estuaries under circumstance not normally considered under WSE. In a December 15, 2003,

letter, the Service agreed that the action was likely to provide a net benefit to the system, with benefits in the lake's littoral zone and relatively low risk of harm to the estuaries due to the moderate discharge volumes. The low level releases were also considered beneficial in attempting to reduce the need for higher volume releases later in the wet season.

On May 13, 2004, the Corps issued a letter requesting extension of the temporary deviation until May 31, 2005. The Service concurred with this request on June 2, 2004. The low volume releases would preclude or lessen high volume regulatory discharges to the Caloosahatchee and St. Lucie estuaries.

On September 10, 2004, the Corps provided to the Service a draft Environmental Assessment (EA) that analyzed the Class Limits Adjustment (CLA) alternative, which was a new proposal to adjust the WSE in order to give lake managers more flexibility in making water release decisions. This was based on a reclassification of hydrologic condition indicators of relative wetness and dryness in the Kissimmee River basin. The Corps concluded that the CLA alternative would not adversely affect listed species or critical habitat, and they requested our review of the EA and comments.

On November 1, 2004, Service provided comments on the draft EA for the CLA alternative. Our evaluation concluded that while the CLA may result in minor negative effects to the estuaries, beneficial ecological effects (also minor) within the lake would offset these effects.

On December 2, 2004, the Corps sent a letter to the Service that included additional information on their effects determination of the CLA on listed species. This was a request for our concurrence with their determination of "no effect" on the Cape Sable seaside sparrow, West Indian manatee and eastern indigo snake, and a "not likely to adversely affect" determination on the snail kite, bald eagle, wood stork and Okeechobee gourd.

The Service responded to the Corps on January 20, 2005. This letter reminded the Corps of our previous request for the Corps to implement a monitoring study on the apple snail within the littoral zone of the lake, which had not been carried out to date. We also informed the Corps that the current scientific information available indicated that the snail kite was faring poorly in Florida, particularly in the littoral zone of Lake Okeechobee, which was historically one of the largest kite breeding areas in the state. We recommended that the Corps immediately reinstitute formal consultation on the Lake Okeechobee regulation schedule, and agreed that the CLA should be implemented as an interim conservation measure while we continue into formal consultation.

On July 21, 2005, the Corps sent a letter to the Service and other stakeholders requesting our initial input on concerns regarding the WSE regulation schedule, and opinions on how problems with the schedule may be addressed.

On August 3, 2005, the Corps issued a Notice of Intent to prepare a Draft SEIS that stated their intention to evaluate new alternatives for the Lake Okeechobee regulation schedule "in order to

optimize environmental benefits at minimal or no impact to the competing project purposes, primarily flood control and water supply.”

The Corps sent a species list request to the Service on August 29, 2005, and the Service responded by letter with the species list on September 30, 2005.

The Service sent a letter to the Corps on September 19, 2005 in response to its July 21 request for initial comments, providing a discussion of our views and issues regarding the lake regulation schedule. A PDT was established to develop and analyze alternatives to the WSE regulation schedule. The selected alternative was to be implemented for the 2007-2009 timeframe. The PDT was composed of representatives and ecological experts from the Corps, the Service, the District, and other local, state and federal agencies.

On March 8, 2006, the Corps requested informal consultation concerning a new regulation schedule, with the stated goal to “plan measures to further improve the environmental performance of the [WSE] regulation schedule.”

On May 16, 2006, the Service sent a letter to the Corps presenting the Service’s official recommendation to select Alternative 1aS2 for the new regulation schedule. The Service considered all ecological effects of the many alternatives that had been modeled, both within and outside Lake Okeechobee. Of particular concern was the effect of other simulated alternatives on lake releases to the downstream estuaries. We emphasized that the selected plan, if unable to provide actual restoration of these estuarine systems, should at least not cause any additional damage to the estuaries than the “future without project” condition. Alternative 1aS2 was identified by the project team as being the best “all around” alternative, which provided the best balance between lowering the lake stage, and controlling large discharges to the estuaries.

In May 2006, the Corps informed the PDT that emphasis of the project objectives had shifted to increase the importance of Herbert Hoover Dike safety over other project objectives. The high water elevation constraint for dike safety was lowered and given greater importance than it previously had. Consequently, those alternatives that did not lower the lake stage to the desired extent were eliminated from further consideration, including our previously recommended Alternative 1aS2, because of human health and safety.

On June 30, 2006, the Corps requested initiation of formal consultation on the new regulation schedule, and submitted a Biological Assessment (BA) presenting its analysis of the effects of the recommended plan on several listed species. The alternative chosen as the TSP was Alternative 1bS2-m. The Service acknowledged the receipt of the BA and began formal consultation on July 21, 2006.

On August 10, 2006, the Corps published the Draft Supplemental Environmental Impact Statement (SEIS) for public review. A draft FWCA report was not completed in time for inclusion in the Draft SEIS. The Service submitted comments on the Draft SEIS as part of a unified comment letter from the Department of the Interior. Public comments on the proposed TSP were overwhelmingly negative, with the majority coming from residents and organizations

on the Florida Gulf coast, due to increased negative impacts that the proposed TSP would have on the Caloosahatchee River and estuary.

Throughout November and December 2006, the PDT developed and analyzed several new variations of the project alternatives, with Alternative T3 selected as the new TSP. (Note: the Corps changed the name of Alternative T3 in their revised draft SEIS to Alternative E, which is how we shall refer to this alternative for the remainder of this document.) The Corps decided to prepare a revised draft of the SEIS that would be subject to a second round of public review. The Service completed a draft FWCA report to be included with the revised draft SEIS. Following a public comment period and preparation of the final SEIS, the Record of Decision for the new schedule should be approved by December 2007.

On February 6, 2007, the Service met with Dr. Wolf Mooij, who is the principal investigator and developer of the “Everkite” population model for the snail kite. Part of our discussions dealt with the Service’s questions on the degree of effect the model predicted on the snail kite population in response to moderate lowering of the stage hydrograph in Lake Okeechobee. We discussed possible explanations as to why the results did not conform with our best professional judgment, and potential modifications to the model that might more accurately account for the adverse effects of high water in addition to the effects of drought, both of which are the primary influences in the outcome of the simulations.

The release date of the revised draft SEIS was delayed several times through July 2007 due to unresolved issues related to Minimum Flows and Levels and the District’s water shortage management rules.

BIOLOGICAL OPINION

DESCRIPTION OF PROPOSED ACTION

Proposed action

The Corps proposes to implement a new regulation schedule for Lake Okeechobee that considers only operational changes to water management structures that discharge water from the lake, with no new construction. This schedule is planned to be active for three years (2007-2010), and a new schedule, which will incorporate possible structural improvements along with water storage benefits from initial components of the Band 1 CERP and Acceler8 projects, will be implemented around the 2010 timeframe.

The proposed water regulation schedule will replace the current WSE regulation schedule. The proposed schedule, known as Alternative E, was identified by the PDT to be the alternative that best met the goal of minimizing threats to the integrity of the Herbert Hoover Dike, while providing some environmental benefits to portions of the system, and not negatively affecting any downstream ecosystems more than they already experience under the existing schedule. The reason for the prominence of the flood control goal is that extended periods of high water levels

(above 17.25 ft) have been identified by the Corps as causing potential integrity issues to the Herbert Hoover Dike.

Refer to the draft FWCA report (Service 2007) for a complete description of the entire series of alternatives evaluated for this project. Alternative E is the final derivation of a series of alternatives developed from the current WSE regulation schedule, with the following changes:

- Changed the late season break points from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address the potential of late season hurricanes.
- Inclusion of an Oct. 1 breakpoint at 13.0 ft for the bottom of the base flow Zone D0 (provides some protection to low lake levels at the end of the wet season).
- Increased Caloosahatchee Level 1 pulse from average daily rate of 1,600 cubic feet per second (cfs) to 2,000 cfs (allows for increased releases below 2,800 cfs to reduce higher lake levels and the associated higher releases).
- Increased Caloosahatchee Level 2 pulse from average daily rate of 2,300 cfs to 2,500 cfs (allows for increased releases below 2,800 cfs to reduce higher lake levels and the associated higher releases).
- Caloosahatchee Level 3 pulse remains unchanged, at average daily rate of 3,000 cfs.
- Reduce maximum Caloosahatchee discharges from 4,500 cfs to 4,000 cfs when the Lake Okeechobee stage is within the intermediate (normal to wet) or low (very wet) bands.

The proposed regulation schedule is depicted using four graphics. Figure 1 shows the actual regulation schedule, with operational bands delineated for specific water elevations throughout the year. Regulatory releases made at specific times of the year are determined through a combination of this regulation schedule, two decision trees (one for releases to the WCAs, and one for releases to the estuaries) depicted in Figures 2 and 3, and an Operational Guideline, shown in Figure 4. Refer to the revised draft SEIS (Corps 2007) for a detailed description of the decision making process for regulatory water releases during normal operational conditions.

Appendix A of the Draft SEIS describes overall operational guidance for the LORS. That guidance emphasizes the need for Additional Operational Flexibility (previously known as Non-Typical Operations) for water managers to be able to respond to unanticipated events outside of the normal predictive capability of the TSP modeling. The Corps states in the Draft SEIS that this additional operational flexibility would be rarely invoked, but the circumstances it describes that would warrant implementation of the increased operational flexibility are very broad.

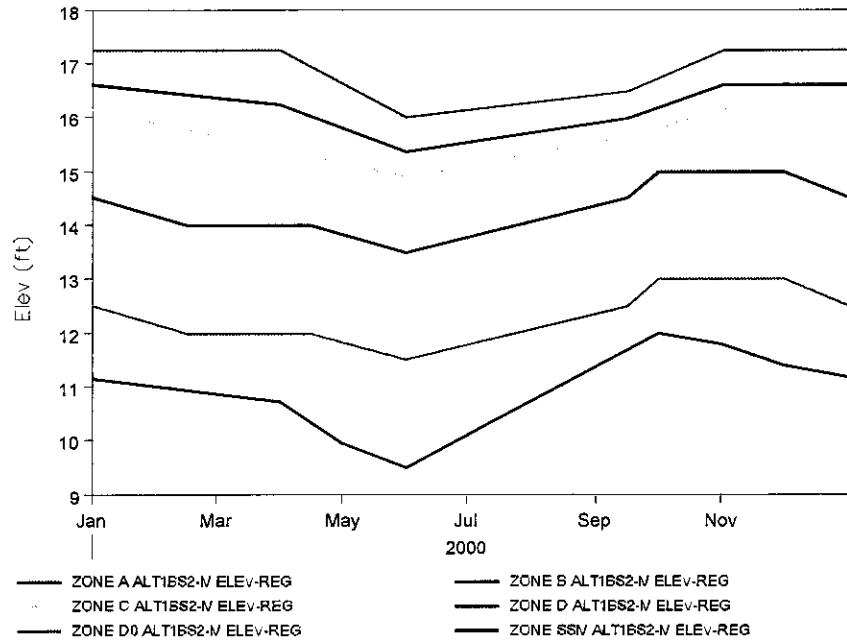


Figure 1. Lake Okeechobee proposed regulation schedule with operational bands (Corps 2007).

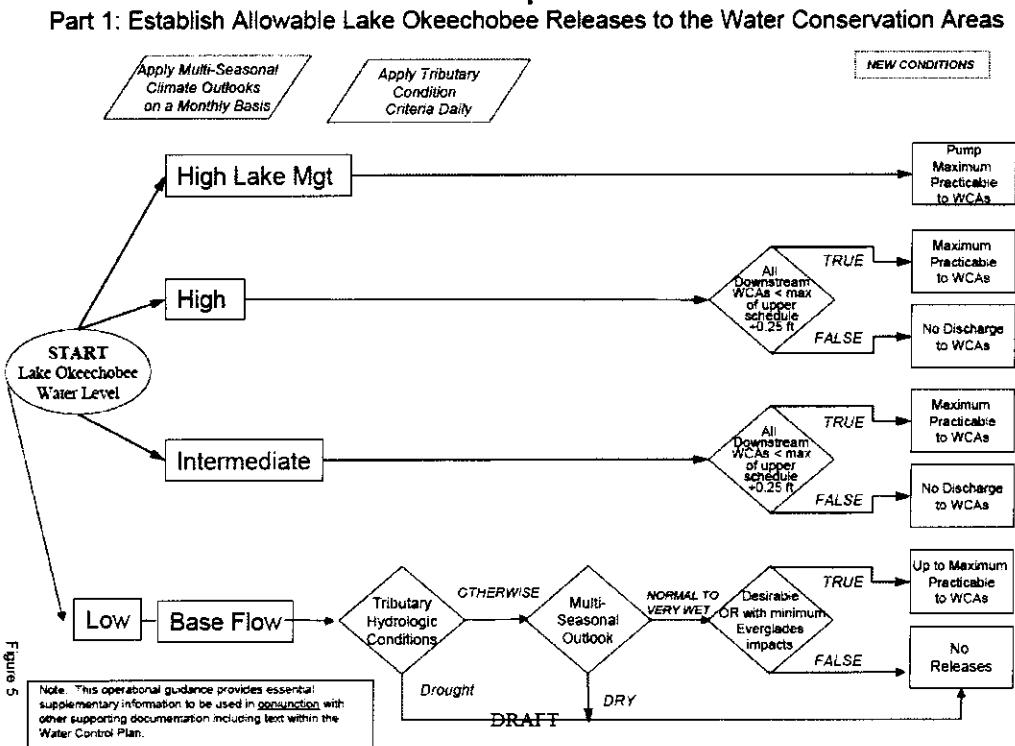


Figure 2. Lake Okeechobee proposed regulation schedule decision tree for releases to WCAs (Corps 2007).

Part 2: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)

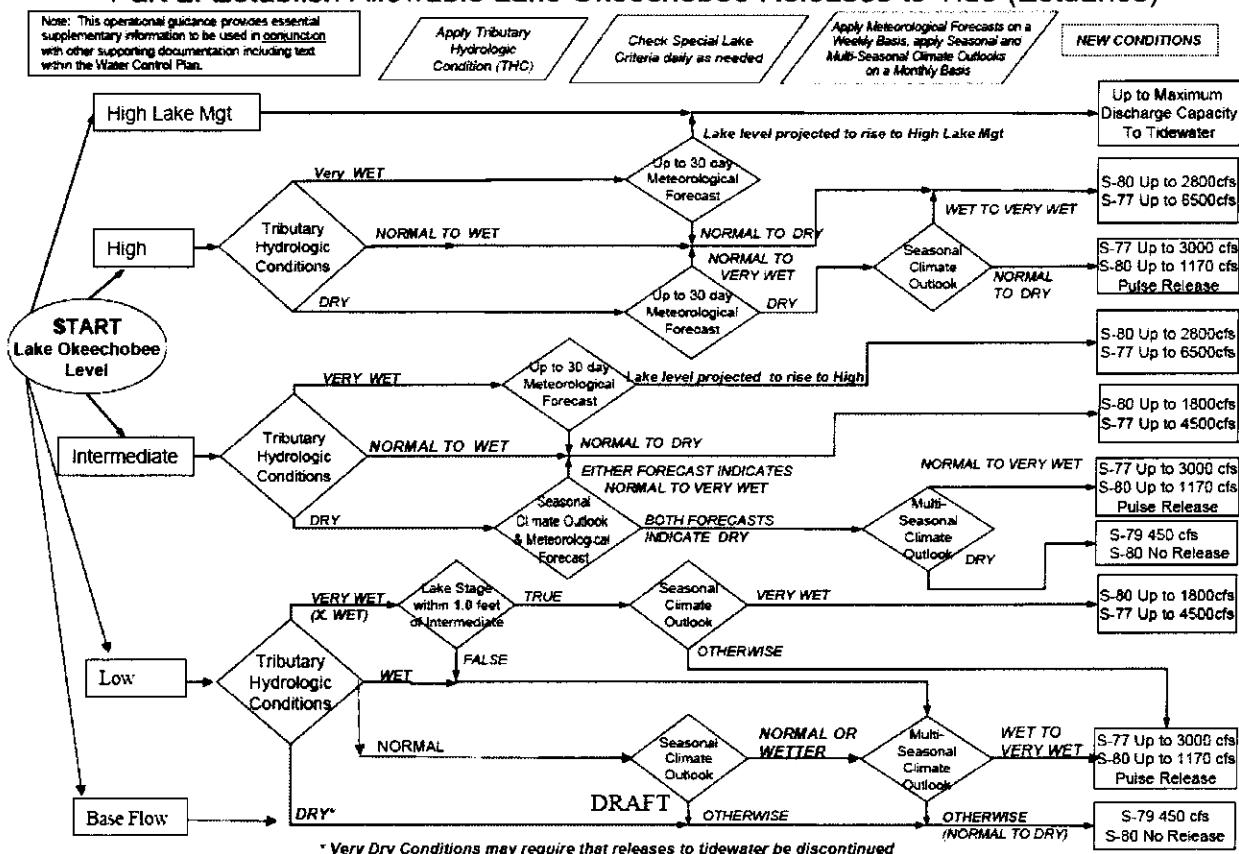


Figure 3. Lake Okeechobee proposed regulation schedule decision tree for releases to estuaries (Corps 2007).

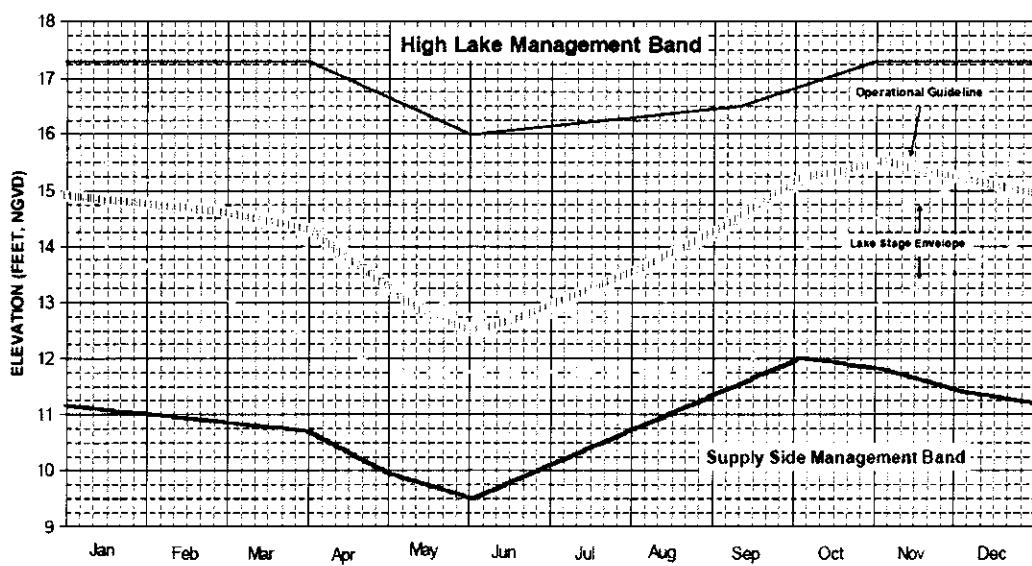


Figure 4. Lake Okeechobee proposed regulation schedule operational guideline.

Action area

The regulations implementing Section 7 of the Act define the action area as all areas in which a listed species can be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.2). Service policy defines the action area as the area that encompasses the geographic extent of environmental changes (i.e., the physical, chemical and biotic effects) that will result directly and indirectly from the action. The geographic scope of the analysis of the LORS alternatives included Lake Okeechobee itself, the St. Lucie and Caloosahatchee estuaries, the WCAs, and Everglades National Park (ENP). However, the snail kite can be found foraging in wetlands outside of this area.

In this case, the direct effects of the action are in Lake Okeechobee, and the indirect effects include the downstream areas hydrologically connected to Lake Okeechobee, and those areas where the behavior of the snail kite may be altered. We have included the downstream WCAs as part of the action area, but have determined that the effects on snail kite habitat in those areas are negligible. The action may also affect the St. Lucie and Caloosahatchee estuaries, but the snail kite generally does not use those brackish habitats. This biological opinion describes a nomadic species that can move among various wetland habitats in central and south Florida. While the proposed action is not deemed to have direct or indirect effects on habitat conditions in other portions of the species' range, such as the Kissimmee Chain of Lakes, the St. Johns Marsh, or the Grassy Waters Preserve, this opinion places the proposed action in the context of the overall distribution of the species, for it may affect the behavior of the species itself. Therefore, we have defined the action area for this consultation to include the entire range of the Everglade snail kite (Figure 5).

STATUS OF THE SPECIES/CRITICAL HABITAT

Species/critical habitat description

The Everglade snail kite is one of three subspecies of snail kite, a wide-ranging New World raptor found primarily in lowland freshwater marshes in tropical and subtropical America from Florida, Cuba, and Mexico south to Argentina and Peru. The Everglade subspecies occurs in Florida and Cuba, though only the Florida population is listed. The Florida population was first listed under the Endangered Species Preservation Act in 1967 (Service 1967), and protection was continued under the Endangered Species Conservation Act of 1969. The Everglade snail kite, and all other species listed under the Endangered Species Conservation Act were the first species protected under the Act, as amended, and all of these species were given the 'endangered' status.

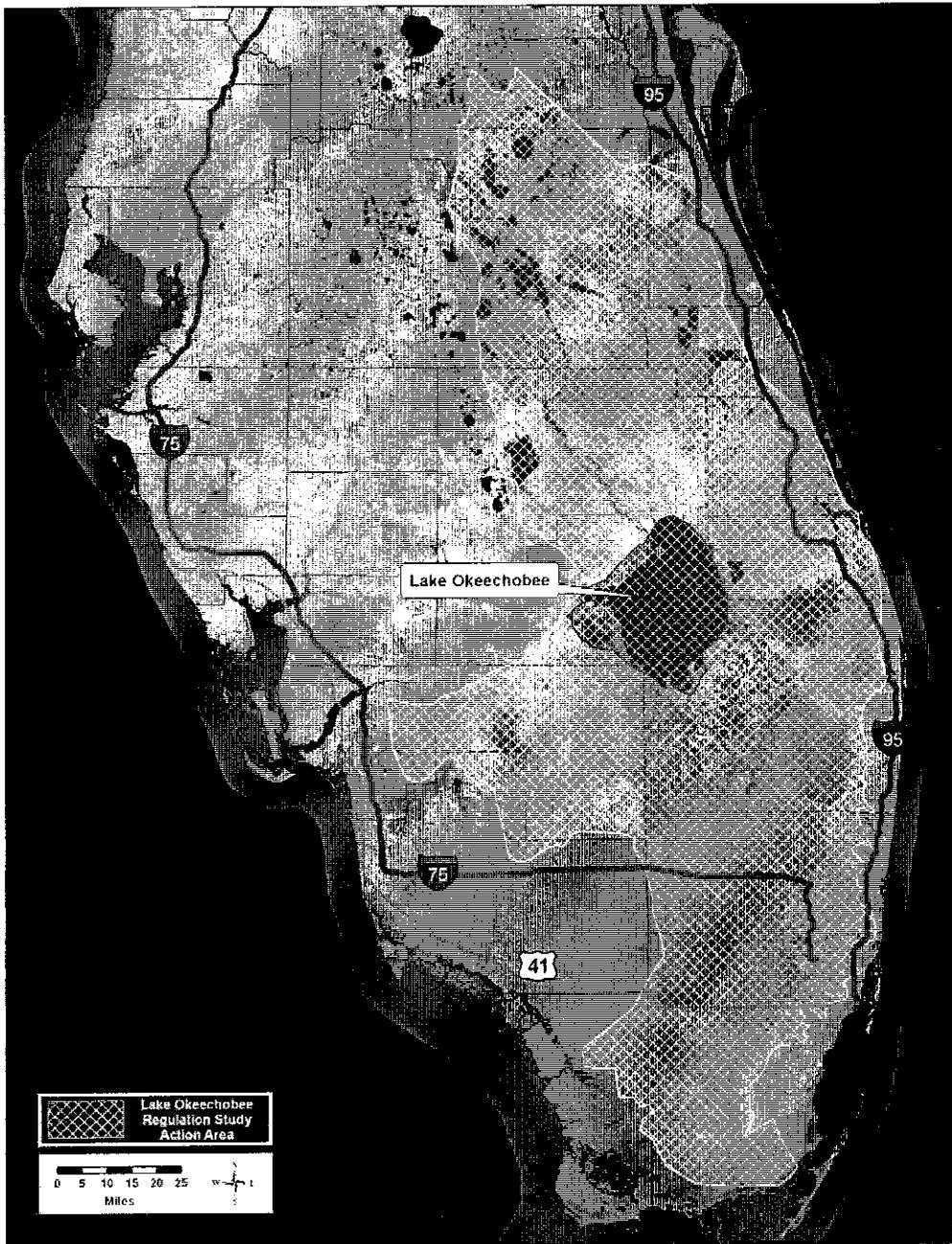


Figure 5. Action area for the formal consultation on the LORSS. (The analysis of performance during plan formulation and for species other than the snail kite was broader.)

Species Description

The snail kite is a medium-sized raptor, with a total body length for adult birds of 14 to 15.5 in and a wingspan of 43 to 46 in (Sykes et al. 1995). In both sexes, the tail is square-tipped with a distinctive white base that appears as a white patch on the rump when in flight. The wings are broad, long, and paddle-shaped and are held bowed downward or cupped when in flight (Sykes et al. 1995). Adults of both sexes have red eyes and juveniles have brown eyes (Brown and Amadon 1976; Clark and Wheeler 1987). The plumage is markedly different among adult male, adult female, and juvenile birds. Adult males have a uniformly slate gray plumage, and adult female plumage is brown dorsally and pale white to cream ventrally, with dark streaking on the breast and belly (Sykes et al. 1995). Immature kites are similar in appearance to adult females but are more cinnamon-colored, with tawny or buff-colored streaking rather than brown streaking. Females are slightly larger than males. The slender, decurved bill is an adaptation for extracting the kite's primary prey, the apple snail; the bill is a distinguishing character for field identification in both adults and juveniles.

Critical Habitat

Critical habitat for the Everglade snail kite was designated in 1977 (Service 1977). The designation identified nine units of critical habitat (Table 2) that included two small reservoirs, the littoral zone of Lake Okeechobee, and areas of Everglades' marshes within the WCAs and ENP (Figure 6). In total, about 841,635 acres were included in the designation. Because this designation was one of the earliest under the Act, primary constituent elements were not defined. We describe in later sections the habitat conditions that are essential to the conservation of the snail kite, in particular the abundance and availability of apple snails as prey for the snail kite. The presence of suitable nesting substrate is another essential component of snail kite critical habitat. Although in 1977 there was no requirement to describe in detail the primary constituent elements of critical habitat, based on the snail kite's consistent use of the Lake Okeechobee littoral zone as foraging and nesting habitat, we are confident that these elements were present at the time that the critical habitat was designated. As evidence, we cite Stieglitz and Thompson's (1967) description of Lake Okeechobee snail kite habitat:

Moonshine Bay, which includes several thousand acres in the southwestern part of the lake, has had the most use; it is generally open marsh, vegetated by low-growing grasses and other emergent aquatics. A few very small Islands, covered by dense, low vegetation, are scattered through the marsh. The open marsh gradually intergrades with moderately dense sawgrass, which in turn gives way to low shrubs and trees on the highest elevations.

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. 402.02, which has been invalidated by court decision, e.g., Sierra Club v. USFWS, 245 F.3d 434 (5th Cir. 2001). Instead, we have relied upon the statutory provisions of the Act to complete the following analysis with respect to critical habitat.

Since designation of critical habitat, the Service has consulted on the loss of 18.66 acres of critical habitat by the construction of C&SF infrastructure . A Biological Opinion, dated September 12, 2006, addressed the effects of construction of the Miccosukee Tribe's Government Complex Center, which resulted in loss of 16.88 acres of critical habitat. In addition, the Service has consulted on impacts to 88,000 acres of critical habitat resulting from prolonged flooding and temporary degradation of critical habitat because of prescribed fire. In addition to these projects, degradation of snail kite critical habitat has occurred because of the effects of long-term hydrologic management and eutrophication. While it is not possible to estimate accurately the changes that have occurred within each unit, about 40 percent of the original designation is estimated to be in a degraded condition for snail kite nesting and foraging relative to when it was designated. For further discussion on effects to critical habitat, see the "Environmental Baseline" section, and "Factors affecting species environment within the action area." In the "Environmental Baseline" section, we summarize several formal consultations on actions in the WCAs and ENP, which form part of the snail kite's critical habitat. We also mention a formal consultation on the Blue Cypress Water Management Plan, which includes designated critical habitat in the St. Johns Marsh in Indian River County. While the Kissimmee Chain of Lakes is now considered an important habitat for the snail kite, this was not the case when critical habitat was designated in 1977, and it is not designated as such.

Table 2. Everglade snail kite critical habitat units and acreage.

Critical Habitat Unit Description	Acres
St. John's Reservoir, Indian River County	2,075
Cloud Lake and Strazzulla Reservoirs, St. Lucie County	816
Western Lake Okeechobee, Glades and Hendry Counties	85,829
Loxahatchee National Wildlife Refuge, Palm Beach County	140,108
WCA-2A, Palm Beach and Broward Counties	106,253
WCA-2B, Broward County	28,573
WCA-3A, Broward and Miami-Dade Counties	319,078
ENP, Miami-Dade County	158,903
TOTAL	841,635

Life History

Everglade snail kites are dietary specialists, a relatively rare foraging strategy among raptors. The Florida apple snail is the kite's principal prey in Florida, and makes up the great majority of the kites' diet (Sykes 1987a; Kitchens et al. 2002). Throughout the range of all subspecies of snail kites, *Pomacea* snails consistently compose the primary prey of snail kites (Sykes 1987a; Beissinger 1990). Kites possess several unique adaptations that allow them to efficiently capture, extract, and consume *Pomacea* snails (e.g., the slender, deeply hooked sharp-tipped bill that allows kites to efficiently extract snails from their shells, long slender toes that allow kites to grasp large snails) (Sykes et al. 1995; Beissinger 1990). Under normal conditions, Everglade snail kites are nearly completely dependent on apple snails as prey. However, other prey items have been documented. Beissinger (1990) reported that kites captured and consumed small turtles such as the musk turtle (*Sternotherus odoratus*) and mud turtles (*Kinosternon* spp), and

they captured and consumed another type of small freshwater snail (*Viviparus georgianus*). Other prey that have been occasionally documented include crayfish (*Procambarus* spp.), speckled perch (*Pomoxis nigromaculatus*), and small snakes (Sykes et al. 1995).

Several species of non-native apple snails have become established recently within limited areas of Florida and have been used to varying degrees by snail kites. Takekawa and Beissinger (1983) reported kite use of the non-native *Pomacea bridgesii*, and snail kites now regularly forage on a relatively newly-arrived non-native apple snail species that currently occurs at high densities within Lake Tohopekaliga, Osceola County, Florida (Kitchens 2006). This snail species was initially suspected to be *Pomacea canaliculata*, but recent research suggests that it is now suspected to be *Pomacea haustrom* (Collins and Rawlings 2006). Despite the use of these other species for foraging, all available evidence suggests that snail kites are still primarily dependent on Florida apple snails. Beissinger (1990) reported that use of turtles and other snail species occurred primarily during periods of limited prey availability such as drought conditions or cold spells. The specializations that allow the snail kite to so efficiently capture and extract apple snails make it difficult for them to capture and eat other alternative prey items (Beissinger 1990). The snail kite may be relatively well-adapted to capture and consume non-native *Pomacea* species, but preliminary information suggests that snail kites may only be able to successfully extract the flesh from a small portion of the presumed *P. haustrom* due to their large size. Juvenile kites that are reliant on these non-native snails may not be able to sustain themselves, despite the fact that snails are abundant (Kitchens 2006). The close tie between the Everglade snail kite and the Florida apple snail requires consideration of both species when developing management strategies and addressing potential impacts.

Everglade snail kites and their primary prey are both wetland-dependent species that rely on wetland habitats for all aspects of their life history. The primary wetland habitat types upon which kites rely consist of freshwater marshes and the shallow vegetated littoral zones along the edges of lakes (natural and man-made) where apple snails occur in relatively high abundance and can be found and captured by kites.

Snail kites use two visual foraging methods: course-hunting, while flying 5 to 33 ft above the water surface, or still-hunting from a perch (Sykes 1987a; Sykes et al. 1995). While course-hunting, the flight is characterized by slow wing beats, alternating with gliding; the flight path is usually into the wind, with the head oriented downward to search for prey. Snails are captured with the feet at or below the surface, to a maximum reach of about 6 inches below the surface. Snail kites do not plunge into the water to capture snails and never use the bill to capture prey. Individuals may concentrate hunting in a particular foraging site, returning to the same area as long as foraging conditions are favorable (Cary 1985). Capture rates are higher in summer than in winter (Cary 1985), with no captures observed at a temperature less than 50°F. Snail kites frequently transfer snails from the feet to the bill while in flight to a perch. Feeding perches include living and dead woody-stemmed plants, blades of sawgrass and cattails, and fence posts.

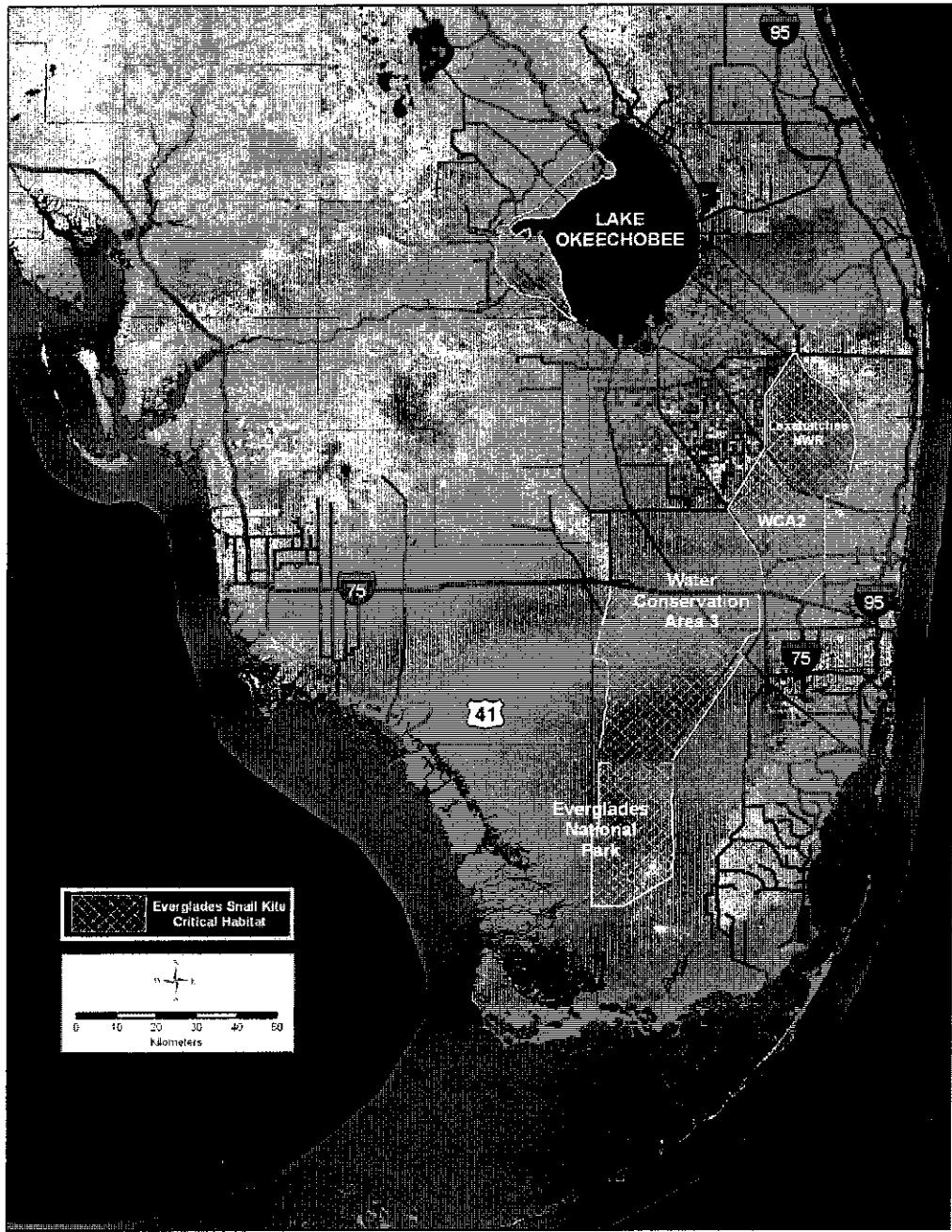


Figure 6. Everglade snail kite critical habitat from Lake Okeechobee south..

While kites are capable of foraging successfully under a variety of habitat conditions, the preferred foraging habitat is typically a combination of relatively short-stature (less than 6.5 ft tall), sparse graminoid marsh vegetation. The apple snail requires emergent aquatic plants to provide substrate that allows them to reach the water surface to breathe. However, for kites to feed, the emergents must be sparse enough that they are capable of locating and capturing snails

(Kitchens et al. 2002). Marshes and lake littoral zones composed of interdigitated areas of open water 0.6 to 4.3 ft deep which is relatively clear and calm and patches of herbaceous emergent wetland plants or sparse continuous growth of herbaceous wetland plants generally provide the appropriate balance of emergent vegetation and open water (Sykes et al. 1995; Kitchens et al. 2002). Marsh species that commonly occur within favorable kite foraging habitat include spikerush (*Eleocharis cellulosa*), maidencane (*Panicum hemitomon*), sawgrass (*Cladium jamaicense*), bulrush (*Scirpus* spp.), and/or cattails (*Typha* spp.). Shallow open-water areas may also contain sparse cover of species such as white water lily (*Nymphaea odorata*), arrowhead (*Sagittaria lancifolia*), pickerel weed (*Pontederia lanceolata*), and floating heart (*Nymphoides aquatica*).

Periphyton growth on the submerged substrate provides food source for apple snails, and submergent aquatic plants such as bladderworts (*Utricularia* spp.) and eel grass (*Vallisneria* spp) may contribute to favorable conditions for apple snails while not preventing kites from detecting snails (Sykes et al. 1995). Foraging habitat conditions that differ substantially from those described above will result in either reduced apple snail density or reduced ability of snail kites to locate and capture snails. Vegetation cover that is either too dense or too sparse can result in reduction in the quality of the area as foraging habitat.

The Everglade snail kite breeding season in Florida varies from year to year and is probably affected by rainfall and water levels (Sykes et al. 1995). Ninety-eight percent of the nesting attempts are initiated from December through July, while 89 percent are initiated from January through June (Sykes 1987c; Beissinger 1988; Snyder et al. 1989), with the peak in nest initiation occurring from February to April (Sykes 1987c). Snail kites often renest following failed attempts early in the season, as well as after successful attempts (Beissinger 1986; Snyder et al. 1989), but the actual number of clutches per breeding season is not well documented (Sykes et al. 1995).

Pair bonds are established prior to egg-laying and are relatively short, typically lasting from nest initiation through most of the nestling stage (Beissinger 1986, Sykes et al. 1995). Male kites select nest sites and conduct most nest-building, which is probably part of courtship (Sykes 1987c; Sykes et al. 1995). Unlike most raptors, snail kites do not defend large territories and frequently nest in loose colonies or in association with wading bird nesting colonies (Sykes 1987b; Sykes et al. 1995). Kites actively defend small territories extending about 4 miles around the nest (Sykes 1987b). Copulation can occur from early stages of nest construction, through egg-laying, and during early incubation if the clutch is not complete. Egg-laying begins soon after completion of the nest, but may be delayed a week or more (Sykes 1987c). An average 2-day interval between laying each egg results in the laying of a three egg clutch in about 6 days (Sykes et al. 1995). The clutch size ranges from 1 to 5 eggs, with a mode of three (Sykes 1987c; Beissinger 1988; Snyder et al. 1989). Incubation may begin after the first egg is laid, but generally after the second egg (Sykes 1987c). In Florida, the incubation period lasts 24 to 30 days (Sykes 1987c). Incubation is shared by both sexes, but the contribution of incubation time between the male and female is variable (Beissinger 1987). Hatching success is variable from year to year and between areas. In nests where at least one egg hatched, hatching success averaged 2.3 chicks per nest (Sykes 1987c).

After hatching, both parents initially participate in feeding young, but there is variability in the contribution of each member of the pair (Beissinger 1987). The nestling period lasts about 23 to 34 days and fledging dates may vary by 5 days among chicks (Sykes et al. 1995). Following fledging, young are fed by one or both adults until they are 9 to 11 weeks old (Beissinger 1987). In total, snail kites have a nesting cycle that lasts about 4 months from initiation of nest-building through independence of young (Beissinger 1986; Sykes et al. 1995).

Snail kites also have a relatively unique mating system in Florida that is described as ambisexual mate desertion, in which either the male or female may abandon nests part way through the nestling stage (Beissinger 1986, 1987). This behavior appears to occur primarily under conditions when prey is abundant, and it may be an adaptation to maximize productivity during favorable conditions. Following abandonment, the remaining parent continues to feed and attend chicks through independence (Beissinger 1986). Abandoning parents presumably form new pair bonds and initiate a new nesting attempt. Snail kites mature early compared to other raptors and can breed successfully the first spring after they hatch, when they are about 8 to 10 months old. However, not all kites breed at this age. Bennetts, Golden et al. (1998) reported that only three out of nine first-year snail kites attempted to breed, while all of 23 adults that were tracked attempted to breed. Of the 23 adult kites, 15 attempted to breed once, 7 attempted to breed twice, and one individual attempted to breed three times. Only one adult kite successfully fledged two clutches. Adult kites generally attempt to breed every year with the exception of drought years when some kites may not attempt to nest (Sykes et al. 1995).

Nesting almost always occurs over water, which deters predation (Sykes 1987b). An important feature for snail kite nesting habitat is the proximity of suitable nesting sites to favorable foraging areas. Thus, extensive stands of contiguous woody vegetation are generally unsuitable for nesting and suitable nest sites consist of single trees or shrubs or small clumps of trees and shrubs within or adjacent to an extensive area of suitable foraging habitat. Trees usually less than 32 ft tall are used for nesting, and include willow (*Salix* spp.), bald cypress (*Taxodium distichum*), pond cypress (*Taxodium ascendens*), *Melaleuca quinquenervia*, sweetbay (*Magnolia virginiana*), swamp bay (*Persea borbonia*), pond apple (*Annona glabra*), and dahoon holly (*Ilex cassine*). Shrubs used for nesting include wax myrtle (*Myrica cerifera*), cocoplum (*Chrysobalanus icaco*), buttonbush (*Cephaelanthus occidentalis*), *Sesbania* sp., elderberry (*Sambucus simpsonii*), and Brazilian pepper (*Schinus terebinthifolius*). Nesting also can occur in herbaceous vegetation, such as sawgrass (*Cladium jamaicense*), cattail (*Typha* sp.), bulrush (*Scirpus* sp.), and reed (*Phragmites australis*) (Sykes et al. 1995). Nests are more often observed in herbaceous vegetation around Lake Kissimmee and Lake Okeechobee during periods of low water when dry conditions beneath the willow stands (which tend to grow to the landward side of the cattails, bulrushes, and reeds) prevent snail kites from nesting in woody vegetation. Nests constructed in herbaceous vegetation on the waterward side of the lakes' littoral zone are more vulnerable to collapse due to the weight of the nests, wind, waves, and boat wakes and are more exposed to disturbance by humans (Chandler and Anderson 1974; Sykes and Chandler 1974; Sykes 1987b; Beissinger 1986, 1988; Snyder et al. 1989).

Adult snail kites have relatively high annual survival rates, with estimated average rates ranging from 85 to 98 percent (Nichols et al. 1980; Bennetts, Dreitz et al. 1999; Martin, Kitchens et al. 2006). Adult survival is probably reduced in drought years (Takekawa and Beissinger 1989; Martin, Kitchens et al. 2006). Adult longevity records in the wild are more than 15 years, and kites may frequently live longer than 13 years in the wild (Sykes et al. 1995).

Everglade snail kites may roost communally outside of breeding season, and occasionally roost in groups of up to 400 or more individuals (Bennetts et al. 1994). Roosting sites are also usually located over water. On average, in Florida, 91.6 percent are located in willows, 5.6 percent in *Melaleuca*, and 2.8 percent in pond cypress. Roost sites are in taller vegetation among low-profile marshes. Snail kites tend to roost around small openings in willow stands at a height of 5.9 to 20.0 ft, in stand sizes of 0.05 to 12.35 acres. Roosting also has been observed in *Melaleuca* or pond cypress stands with tree heights of 13 to 40 ft (Sykes 1985).

Snail kites are considered nomadic, and this behavior pattern is probably a response to changing hydrologic conditions (Sykes 1979). During breeding season, kites remain close to their nest sites until they fledge young or fail. Following fledging, adults may remain around the nest for several weeks, but once young are fully independent adults may depart the area. Outside of the breeding season, snail kites regularly travel long distances within and among wetland systems in southern Florida (Bennetts and Kitchens 1997). While most movements may be in response to droughts or other unfavorable conditions, kites may also move away from wetlands when conditions appear favorable. Movements within large wetlands and movements among adjacent wetland units occurred frequently, while movements among spatially isolated wetlands occurred less frequently (Martin, Nichols et al. 2006). Fledgling kites also move frequently, but are more likely to move to immediately adjacent wetland units than adults, and this may indicate a degree of familiarity with the availability of wetlands across the landscape that adult kites acquire through experience.

Snail kites are highly gregarious. In addition to nesting in loose colonies and roosting communally in large numbers, kites may also forage in common areas in proximity to other foraging kites.

Population dynamics

Everglade snail kites appear to exhibit high levels of variability in some demographic parameters, while others remain relatively constant. For example, distribution of nesting appears to fluctuate dramatically among years. Similarly, productivity appears to be highly variable and heavily influenced by environmental conditions (Sykes 1979; Beissinger 1989, 1995; Sykes et al. 1995). Duration of breeding season and amount of double- or triple-brooding are also variable (Beissinger 1986). Juvenile survival also appears to be highly variable among years (Beissinger 1995; Bennetts and Kitchens 1999; Martin, Kitchens et al. 2006). In contrast, adult survival appears to be relatively constant over time at a relatively high level (Bennetts, Dreitz et al. 1999; Martin, Kitchens et al. 2006), though drought years may result in reduced adult survival (Beissinger 1995; Martin, Kitchens et al. 2006). The combination of these demographic characteristics may allow kites to survive unfavorable conditions, by either moving to other areas

or simply waiting out the unfavorable conditions. Under favorable environmental conditions, kites have the ability to achieve high reproductive rates (Beissinger 1986), and similarly, juvenile survival rates appear to be higher under more favorable conditions.

Relatively large fluctuations in the Everglade snail kite population size have been widely reported and generally attributed to environmental conditions (Beissinger 1986; Beissinger 1995). However, some of these reported fluctuations, and the magnitude of reported declines in particular, may be influenced by the population survey methods (see below) and the fact that kites tend to depart traditional areas when those areas experience unfavorable conditions (Bennetts, Link et al. 1999).

Historic records of snail kite nesting include areas as far north as Crescent Lake and Lake Panasoffke in north-central Florida and as far west as the Wakulla River (Howell 1932; Sykes 1984). Several authors (Nicholson 1926; Howell 1932; Bent 1937) indicated that the snail kite was numerous in central and southern Florida marshes during the early 1900s, with groups of up to 100 birds. Reports of snail kite population declines in the 1940s and 1950s suggested that as few as 6 to 100 individuals remained (Sykes 1979). Reports of declines resulted from disappearance of kites from areas where they had previously occurred in large numbers, including Lake Okeechobee and the headwaters of the St. John's marsh (Sykes 1979). Limited resources were available at that time for researchers to reach potential snail kite habitats, the resulting low level of survey effort may have biased these low snail kite population estimates, and absence of kites from particular areas may have resulted from the kite's nomadic behavior and responses to unfavorable hydrologic conditions (Sykes 1979). However, there is little doubt that the snail kite was endangered at that time and that its range had been dramatically reduced.

When the snail kite was listed as endangered in 1967 (Service 1967), the species was considered to be at an extremely low population level. In 1965, only 10 birds were found, 8 in WCA-2A and 2 at Lake Okeechobee. A survey in 1967 found 21 birds in WCA-2A (Stieglitz and Thompson 1967).

Prior to 1969, the snail kite population was monitored only through sporadic and inconsistent surveys (Sykes 1979, 1984). From 1969 to 1994, an annual quasi-systematic mid-winter snail kite count was conducted by a succession of principal investigators. Counts since 1969 have ranged from 65 in 1972 to 996 in 1994. Bennetts et al. (1993, 1994) cautioned that the 1993 and 1994 counts were performed with the advantage of having numerous birds radio-tagged. This influenced the total count, because radio-tagged birds could be easily located and often led researchers to roosts that had not been previously surveyed. Bennetts and Kitchens (1997) identified issues with the count surveys and recommended that they should not be the basis of population estimates or used to infer demographic parameters such as survival or recruitment. Bennetts, Link et al. (1999) analyzed these counts and the sources of variation in these counts and determined that count totals were influenced by observer differences, differences in hydrologic conditions and effort, and site effects. While significant sources of error were identified, these data could provide a crude indication of trends, if all influences of detection rates had been adequately taken into account. The sources of variation in the counts should be

recognized prior to using these data in subsequent interpretations, especially in attempting to determine population viability and the risk of extinction.

Although sharp declines have occurred in the counts since 1969 (for example, 1981, 1985, 1987), it is unknown to what extent this reflects actual changes in population. Rodgers et al. (1988) have stated that it is unknown whether decreases in snail kite numbers in the annual count are due to mortality, dispersal (into areas not counted), decreased productivity, or a combination of these factors. Despite these problems in interpreting the annual counts, the data since 1969 have indicated a generally increasing trend (Sykes 1979; Rodgers et al. 1988; Bennetts et al. 1994). While acknowledging the problems associated with making year-to-year comparisons in the count data, some general conclusions are apparent. Changes in occurrence and occupancy of individual wetland units are variable among years and the degree of variability among wetlands is also variable. For example, Lake Okeechobee apparently retains some suitable snail kite habitat throughout both wet and dry years and remained relatively continuously occupied from 1969 through the mid-1980s. In contrast, snail kite use of WCAs fluctuates greatly, with low use during drought years, such as 1991, and high use in wet years, such as 1994.

Refined population estimates were generated for the Everglade snail kite using a mark-recapture method beginning in 1997 (Dreitz et al. 2002). These new population estimates which explicitly address detection probability and incorporate corrections to exclude the effects of variable detection probability that affected previous population estimates are higher than those resulting from the previous counts. The population size estimate generated from mark-recapture estimates for 1997-2000 was about 2 to 3 times higher than count-based estimates (estimates of about 800 to 1,000 individuals in 1993 and 1995 based on count-based surveys compared to about 2,700 to 3,500 estimated from mark-recapture analyses from 1997 to 2000) (Bennetts and Kitchens 1997; Dreitz et al. 2002). Confidence intervals can also be generated for population estimates generated using the new method, which increases the validity of comparing population estimates among years.

Since 1997, population estimates and estimates of demographic parameters have been generated exclusively employing mark-recapture methods that incorporate detection probabilities (Figure 7). From 1997 through 1999, the state-wide snail kite population was estimated to have been about 3,000 birds (Dreitz et al. 2002). From 1999 through 2003, the population estimates declined each year until they reached a low level of about 1,162 birds in 2003, then increased slightly to about 1,566 birds in 2005 (Martin, Kitchens et al. 2006). A preliminary estimate of the 2006 snail kite population size is about 1,648 birds (Martin 2007).

This population decline may have been exacerbated by a regional drought that affected southern Florida during 2000 to 2001. During this period, nest success was generally low (Martin, Kitchens et al. 2006), and demographic parameters estimated from mark-recapture methods also indicated that juvenile survival rates were low, and even adult survival declined during 2001 (Figure 8) (Martin, Kitchens et al. 2006). However, following the end of the drought conditions in 2002 and a return to normal or wetter-than-normal hydrologic conditions from 2002 to 2006 that generally provide favorable snail kite nesting conditions, population estimates remained low, and nest success and juvenile survival rates also remained low (Martin, Kitchens et al. 2006).

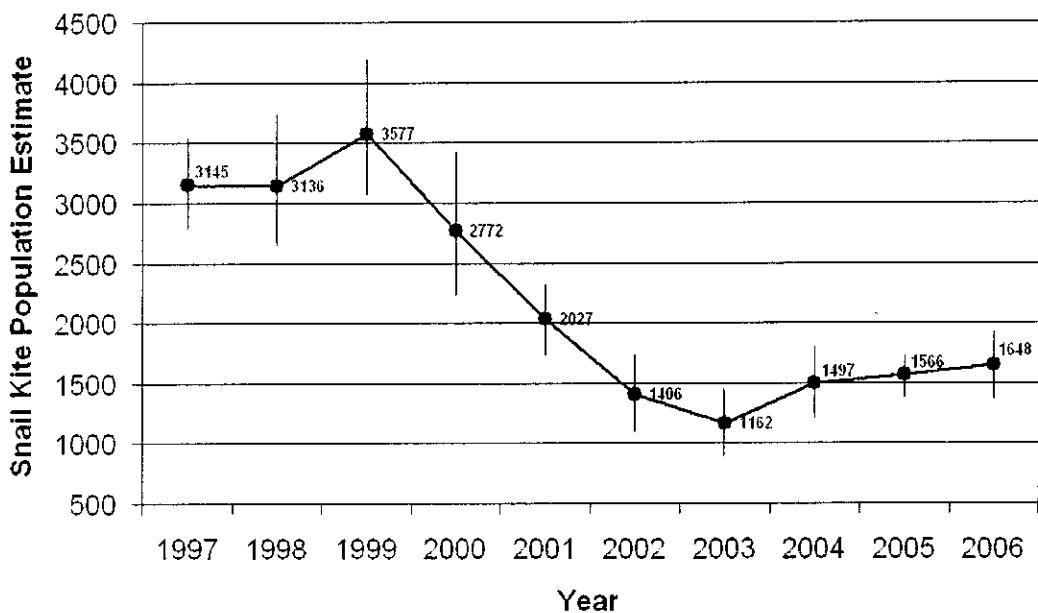


Figure 7. Estimates of state-wide snail kite population size between 1997 and 2006. Error bars correspond to 95 percent confidence intervals (Martin 2007).

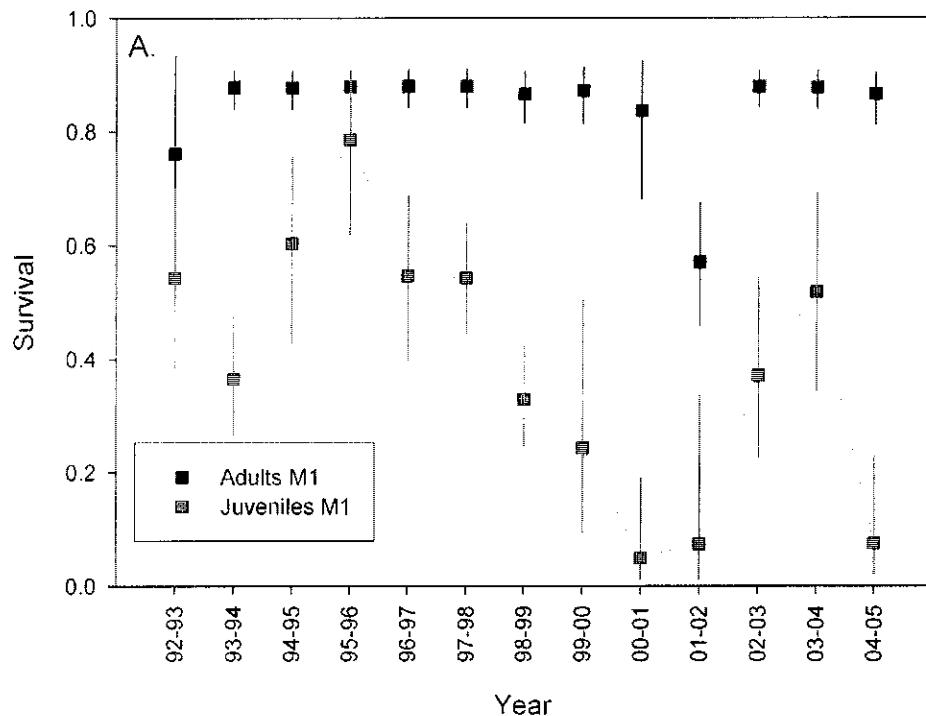


Figure 8. Model-averaged estimates of adult (black squares) and juvenile (green squares) survival between 1992 and 2005. Error bars represent 95 percent confidence intervals (Martin 2007).

As of April 2007, south Florida is passing through an intense and widespread drought covering the entire range of the Everglade snail kite. Although the nesting season is incomplete, we can offer some preliminary observations. Nesting is nearly absent through much of the species' range, including the WCAs, Lake Okeechobee, and St. Johns Marsh. There is evidence of shifting of the breeding population to more intensively use the Kissimmee Chain of Lakes for nesting this year. This shows a level of adaptability and resilience in the population in response to the severe stress of the drought. Despite the increase in nesting activity in the northern lakes, we anticipate that 2007 will be an overall low year for reproduction of the snail kite. We are uncertain what effect this may have on the overall population and distribution of the species in future years. The population estimates using the mark-recapture program will provide information on the potential effect on the species as a whole. We will also be interested in observing how quickly apple snails can return after the drought to an abundance that will support successful snail kite nesting in Lake Okeechobee and the other major wetland complexes essential to the species.

Status and distribution

The subspecies *R. s. plumbeus* occurs in Florida, Cuba (including Isla de la Juventud) and northwestern Honduras. There is no evidence of movement of birds between Cuba and Florida, but this possibility has not been ruled out (Sykes 1979; Beissinger et al. 1983). In Florida, the historic range of the snail kite was larger than at present.

The current distribution of the snail kite in Florida is limited to central and southern portions of the State. Six large freshwater systems are located within the current range of the snail kite: Upper St. Johns marshes, Kissimmee Chain of Lakes, Lake Okeechobee, Loxahatchee Slough, the Everglades, and the Big Cypress basin (Beissinger and Takekawa 1983; Sykes 1984; Rodgers et al. 1988; Bennetts and Kitchens 1997; Rumbold and Mihalik 1994; Sykes et al. 1995). Habitats that support snail kites in the Upper St. Johns drainage include the East Orlando Wilderness Park, the Blue Cypress Water Management Area, the St. Johns Reservoir, and the Cloud Lake, Strazzulla, and Indrio impoundments with most current nesting occurring within the Blue Cypress Water Management Area (Martin, Kitchens et al. 2006). In the Kissimmee Chain of Lakes, snail kites may occur within most of the lakes and adjacent wetlands, with the majority of kite nesting occurring within Lake Kissimmee, Lake Tohopekaliga, and East Lake Tohopekaliga. Lake Okeechobee and surrounding wetlands historically supported significant snail kite nesting and foraging habitats. Most of the recent nesting in Lake Okeechobee has occurred within the expansive marsh in the southwestern portion of the lake and the area southwest of the inflow of the Kissimmee River (Martin, Kitchens et al. 2006). In the Loxahatchee Slough region of Palm Beach County, snail kites may occur throughout the remaining marshes in the vicinity and most frequently nest within Grassy Waters, which is also known as the West Palm Beach Water Catchment Area. Kites may occur within nearly all remaining wetlands of the Everglades region, with recent nesting occurring within WCA-2B, WCA-3A, WCA-3B, and ENP (Martin, Kitchens et al. 2006). Within the Big Cypress basin, snail kites may occur within most of the non-forested and sparsely forested wetlands. Nesting has not been regularly documented in this area in recent years, though some nesting likely occurs.

In addition to the primary wetlands where most kite nesting has been documented, there are numerous records of kite occurrence and/or nesting within isolated wetlands throughout the region. The Savannas State Preserve, in St. Lucie County, the Hancock impoundment in Hendry County, and Lehigh Acres in Lee County are among the smaller more isolated wetlands used by snail kites (Sykes et al. 1995). Takekawa and Beissinger (1989) identified numerous wetlands that they considered drought refugia, which may provide kite foraging habitat when conditions in the larger more traditionally occupied wetlands are unsuitable. Although the above list generally describes the current range of the species, radio tracking of snail kites has revealed that the network of habitats used by the species includes many smaller, widely dispersed wetlands within this overall range (Bennetts and Kitchens 1997). Snail kites may use nearly any wetland within southern Florida under some conditions and during some portions of their life history. However, the majority of nesting continues to be concentrated within the large marsh and lake systems of the Greater Everglades and the Upper St. John's marshes.

While it is not possible to compare the current population size to those recorded from the 1970s through 1997 due to differences in sampling methods, several lines of evidence suggest that the current kite population has declined and may be continuing to decline. Martin, Kitchens et al. (2006) reported that the population has declined by about 50 percent and their estimates result from consistent methods. In addition, the distribution of nesting activity in recent years has suggested that several of the traditional nesting areas were in unfavorable conditions for nesting. Low productivity, both in terms of low rates of nest initiation and low success rates resulting from those initiated nests suggest that conditions were poor for kite nesting in those years. Relatively low juvenile survival rates in recent years also support the conclusion that conditions for kites have been relatively unfavorable due to a variety of factors. There has, however, been the expected annual variation in juvenile survival estimates, with 2002-2004 showing comparatively high rates since 2000.

Studies of apple snail abundance and occurrence within traditional snail kite nesting areas also support conclusions that foraging conditions may be poor. Darby et al. (2005) reported that apple snail abundance has recently declined substantially within WCA-3A. Darby (2005a, 2005b) reported that apple snail abundance remains relatively low in areas of traditional snail kite use within Lakes Kissimmee, Tohopekaliga, and Okeechobee in recent years.

As previously noted, however, adult survival has been relatively constant over time at a relatively high level (Bennetts, Dreitz et al. 1999; Martin, Kitchens et al. 2006), except in 2001 and 2002. This factor helps kites survive unfavorable conditions, and the adults can either move to other areas with favorable conditions or simply wait out the unfavorable conditions. Under favorable environmental conditions, kites have the ability to achieve high reproductive rates (Beissinger 1986), and similarly, juvenile survival rates appear to be higher under more favorable conditions. Barring extreme climatological fluctuations in the coming years, we do not expect a significant change in the health of the population during the duration of this project.

Threats to the species

There are a variety of threats that have been identified which affect kite nesting, foraging, and survival. These threats include loss of wetland habitats, degradation of wetland habitat, changes in hydrologic conditions, and impacts to prey base.

Collapse of nests constructed in herbaceous vegetation is cited as a cause of increased nest failure during low-water years. This is because the water table is usually below the ground surface at willow heads and other stands of woody vegetation during drought, causing snail kites to nest in herbaceous vegetation, where the nests are more vulnerable to collapse. This effect is more prevalent in lake environments than in the Everglades. Weather also can result in the variability of nesting success. Wind storms can cause toppling of nests, particularly on Lake Okeechobee and Lake Kissimmee due to the long wind fetch across these large lakes. Cold weather can also produce nest failure, either through decreased availability of apple snails or mortality of young due to exposure. Abandonment of nests before egg-laying is common, particularly during drought or following passage of a cold front.

The snail kite has apparently experienced population fluctuations associated with hydrologic influences, both man-induced and natural (Sykes 1983a; Beissinger and Takekawa 1983; Beissinger 1986), but the amount of fluctuation is debated. However, the abundance of its prey, apple snails, has been definitively linked to water regime (Kushlan 1975; Sykes 1979, 1983a). Drainage of Florida's interior wetlands has reduced the extent and quality of habitat for both the snail and the kite (Sykes 1983b). The snail kite nests over water and nests become accessible to predators in the event of unseasonable drying (Beissinger 1986; Sykes 1987b). In dry years, snail kites depend on water bodies that normally are suboptimal for feeding, such as canals, impoundments, or small marsh areas, remote from regularly used sites (Beissinger and Takekawa 1983; Bennetts et al. 1988; Takekawa and Beissinger 1989). These secondary or refuge habitats could play an important role in the future.

The principal threat to the snail kite is the loss or degradation of wetlands in central and southern Florida. Nearly half of the Everglades has been drained for agriculture and urban development (Davis and Ogden 1994). The EA alone eliminated 3,100 square-miles of the original Everglades and the urban areas in Miami-Dade, Broward, and Palm Beach Counties have contributed to the reduction of habitat. North of ENP, which has preserved only about one-fifth of the original extent of the Everglades, the remaining marsh has been fragmented into shallow impoundments. The Corps' C&SF Project encompasses 18,000 square-miles from Orlando to Florida Bay and includes about 994 miles each of canals and levees, 150 water control structures, and 16 major pump stations. This system has disrupted the volume, timing, direction, and velocity of freshwater flow.

Degradation of water quality, particularly runoff of phosphorus from agricultural and urban sources, is another concern for the snail kite. The Everglades was historically an oligotrophic system, but major portions have become eutrophic, primarily due to anthropogenic sources of phosphorus and nitrogen (cultural eutrophication). Most of this increase has been attributed to non-point source runoff from agricultural lands north of Lake Okeechobee, in the Kissimmee

River, Taylor Slough, and Nubbin Slough drainages (Federico et al. 1981). Cultural eutrophication also is a concern in the Kissimmee Chain of Lakes. Nutrient enrichment leads to growth of dense stands of herbaceous emergent vegetation, floating vegetation (primarily water hyacinth [*Eichhornia crassipes*] and water lettuce [*Pistia stratiotes*]) and woody vegetation, which inhibits the ability of snail kites to forage along the shorelines of lake areas. Regulation of water stages in lakes and the WCAs is particularly important to maintain the balance of vegetative communities required to sustain snail kites.

Habitat loss to urban and agricultural development continues to occur, even within the current spatial extent of the habitat network. Habitat quality may be deteriorating because of increasing nutrients (Bennetts et al. 1994). Drying events also may be increasing above naturally occurring frequencies as a result of water management (Beissinger 1986).

Attempts to control, reduce and eliminate the spread of invasive and exotic species have also had negative effects on snail kites. Rodgers et al. (2001) describe a program to reduce impacts of aquatic plant management on snail kites. They found that the actions of several agencies in controlling aquatic plants have caused nest collapse, particularly in herbaceous vegetation such as cattail and bulrush. They state that these impacts in Lake Okeechobee and the Kissimmee Chain of Lakes were reduced through cooperation and improved communication between agencies. In addition to the potential collapse of nests, the Service is concerned about any excessive application of herbicides because this would reduce available habitat for apple snails. The Service has expanded on these coordination efforts to notify aquatic plant management groups during the kite nesting season on the location of active snail kite nests (Service 2006) to assist them in avoiding or minimizing take.

ENVIRONMENTAL BASELINE

The environmental baseline includes the effects of past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included are the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impacts from State or private actions that are contemporaneous with the consultation in progress.

An incidental take statement has never been issued to the Corps for impacts of the LORS on the snail kite. Regulations governing incidental take were first published in 1986; since then we have concurred that several proposed (and since implemented) changes to the regulation schedule were not likely to adversely affect the snail kite.

Previous formal consultations on the Everglade snail kite

In addition to the list of consultations on actions affecting the snail kite in Lake Okeechobee (in the Consultation History section of this biological opinion), the Service has evaluated impacts of past Federal actions in accordance with the Act throughout the species' range, including Everglades National Park, the Water Conservation Areas, the St. Johns Marsh, the Kissimmee River, and the Kissimmee Chain of Lakes. For the Kissimmee River Restoration project, we

concluded that it would be beneficial to the snail kite, and therefore did not issue a biological opinion. The following paragraphs list some of the more significant formal consultations, but are not intended to be a comprehensive list of all formal consultations on the snail kite.

Only two biological opinions in our records reached a conclusion that a proposed action was likely to jeopardize the continued existence of the snail kite. The first was in response to the Corps' Regulatory Program regarding a wetland fill permit for a private housing development, Ibis Landing, in Palm Beach County. Our October 22, 1986, opinion called for redesigning the proposed project to avoid impacts on wetlands known to be of great importance as habitat for the snail kite, although these wetlands were not in the designated critical habitat for the species. The permit was issued with a modified design protecting the most important snail kite habitat on the property.

The second jeopardy biological opinion was a February 13, 1990 biological opinion that concluded that the Basic Raindriven Plan for the Modified Water Deliveries to Everglades National Park Project would result in jeopardy. This opinion led to more intensive and extensive studies on the ecology of the snail kite in Florida, and the resulting scientific findings have significantly altered the assumptions of the 1990 opinion, which represented the best available science at that time. Another biological opinion, also focused on hydrology in the southern portion of the snail kite's range, dealt with Test Iteration 7 of the Experimental Program of Water Deliveries to Everglades National Park. Although that October 27, 1995 opinion found that the proposed action was likely to jeopardize the continued existence of the endangered Cape Sable seaside sparrow, it concurred with the Corps' determination of "not likely to adversely affect" for the snail kite. Our February 19, 1999, biological opinion on the Water Deliveries to Everglades National Park project, Experimental Water Deliveries Program, and the C-111 Project again concluded that the proposed action would constitute jeopardy for the Cape Sable seaside sparrow. It concluded that the action would adversely affect, but would not jeopardize the continued existence of, the endangered wood stork and the snail kite, and would not adversely modify the snail kite's critical habitat.

On March 28, 2002, the Service issued a biological opinion on the Interim Operating Plan for Protection of the Cape Sable seaside sparrow (IOP). This opinion found that the proposed action would avoid jeopardy for the sparrow, but would likely have additional adverse effects on the snail kite, exceeding those had the Corps followed the Service's originally proposed Reasonable and Prudent Measure in the 1999 biological opinion. However, we concluded that these adverse effects would not constitute jeopardy for the snail kite. The most recent (November 17, 2006) opinion issued by the Service addressing water management in the southern Everglades also dealt with the IOP. Similar to the actions considered in our 2003 opinion, the emphasis of the Corps' planning was to ensure survival of the sparrow, but we also needed to address effects on other listed species, including the snail kite. The 2006 opinion continued to assert that water management practices to protect the sparrow were not favorable to habitat conditions for the snail kite, particularly with respect to deeper water in WCA 3A. However, the opinion stated that such conditions would not result in jeopardy, that they are expected to be remedied with future improvements to the water control infrastructure, and that we did not anticipate any permanent loss of designated critical habitat for the snail kite. If the reader is interested in more

details regarding the history of Service' endangered species consultation process in the southern Everglades, please refer to the Consultation History section of the 2006 IOP biological opinion.

We consulted formally on another action in the southern portion of the snail kite's range in ENP, but it differed from the above consultations in that it involved the Everglades National Park 2003-2005 Prescribed Burn Plan, rather than water management actions. The Service recognized that periodic fire was necessary to sustain habitat conditions for a variety of wildlife (long-term effects), including the snail kite, but needed to estimate short-term incidental take for the snail kite. We found in our April 1, 2003 biological opinion that adult snail kites were not likely to be injured or killed because of the actions, but prescribed fire may result in direct impacts to kite foraging, nesting habitat, and kite nests. We believed that there would be no mortality of flighted birds, but up to 40 individual kites would be harassed. In a similar analysis of the 2003-2004 Burn Plans on the Loxahatchee National Wildlife Refuge (June 10, 2003), we estimated that only two birds per year would likely be harassed in that habitat to the north.

On September 19, 1996, we issued a formal consultation in response to a Corps permit application by the Florida Department of Transportation to construct three recreational access points along Interstate 75 in Broward County. Interstate 75 runs through WCA 3, and our opinion addressed likely effects on the snail kite, wood stork, and the endangered Florida panther (*Felis concolor coryi*). For the snail kite, we did not anticipate mortality of adult birds, but we anticipated potential additional disturbance of nests, with some loss of eggs or nestlings, primarily due to increased airboat traffic (although the area was already open to airboat use). To reduce the incidental take of all three listed species, we provided terms and conditions, including improved signage and educational materials for potential users about the presence and sensitivity of these species, and improved mapping of established trails.

We formally consulted with the Corps regarding the Water Management Plan for the Blue Cypress Water Management Area, Upper St. Johns River Basin Project. A portion of that Water Management Area is designated as critical habitat for the snail kite, located in western Indian River County. The local sponsor for this project is the St Johns River Water Management District. Our biological opinion, dated November 14, 1996, provided a number of terms and conditions to reduce incidental take, with close monitoring of snail kite activity and habitat usage, vegetation changes, water levels, and water quality.

The Service issued a biological opinion, dated July 3, 2002, which covered the Corps' issuance of a permit to the Florida Fish and Wildlife Conservation Commission to draw down water levels and scrape accumulated organic sediments in Lakes Tohopekaliga, Kissimmee, Cypress, Hatchineha, and Tiger in the Kissimmee Chain of Lakes. This opinion analyzed impacts on the snail kite for a habitat management action that in the longer term has proven to be beneficial to the snail kite, but required granting incidental take for short-term adverse effects. This opinion referred back to previous projects of a similar nature that the Service had reviewed, including lake habitat enhancement projects in Lake Tohopekaliga (1971, 1979, and 1987), Lake Kissimmee (1977 and 1996), and East Lake Tohopekaliga (1990). Again, we provided terms and conditions to reduce incidental take, and the FWC funded a number of studies to test the effects of the management actions (drawdown alone and drawdown with muck removal) on snail

kites, apple snails, and vegetation. Through these studies and subsequent observations, we are confident that such projects can have long-term beneficial effects on snail kite habitat, if they are not conducted too frequently. We have recommended that such actions be rotated among the lakes comprising the Kissimmee Chain of Lakes to allow time between the short-term adverse effects in a single lake.

On October 23, 2003, we provided an intra-Service consultation on the effect of issuance of a recovery permit to Dr. Wiley Kitchens of the University of Florida, and students working under him, to continue research on the species. During the course of their research, they handle many nestling snail kites to band them. We estimated that capture, handling, and banding might result in the accidental injury or death of 1 percent of the snail kites captured. Based on the expectation that up to 300 chicks may be captured per year, up to 3 individual chicks may be injured or killed per year.

We have recently (May 18, 2007) formally consulted on a deviation to the normal regulation schedule for Lake Istokpoga that was requested by the District in response to severe drought. At the time of the consultation, three snail kite nests were active on the lake, for which we had to grant incidental take. As of this writing, the lake stage has not fallen below the level requiring the deviation, and of the three nests, two failed for unknown reasons, and the last fledged prior to the need to invoke the requested deviation.

To date, the Service has not entered into formal consultation on the snail kite for any of the projects identified as part of the District's Acceler8 program. We have formally consulted regarding effects of Acceler8 projects on other species, particularly the threatened eastern indigo snake and Audubon's crested caracara (*Polyborus plancus audubonii*). The C-44 and C-43 projects will be located on former citrus groves, which are generally of low or negligible value as habitat for the snail kite. Likewise, the site of the EAA Reservoir project had been sugarcane fields and some sod farms, neither of which are considered particularly valuable as snail kite habitat. The site of the Picayune Strand Restoration project and the other Acceler8 projects were likewise found not to affect the snail kite. We have recently re-initiated informal consultation with the District on the C-44 project to ensure that copper contamination will not adversely affect snail kites through the food chain. We are working with the District to ensure that they include monitoring of copper concentrations in apple snails to verify that potential foraging by snail kites in the stormwater treatment area of the C-44 project will not pose a risk to the snail kite.

History of habitat changes in Lake Okeechobee

This section summarizes factors affecting the snail kite habitat within the littoral zone of Lake Okeechobee. Because the majority of the suitable snail kite habitat within Lake Okeechobee is designated as critical habitat, all discussion within this document related to the description of, and effects to, snail kite habitat within the lake also apply to the critical habitat within Lake Okeechobee.

During the early 1970s, habitat conditions within the lake were more favorable for apple snails and snail kites, relative to the habitat conditions within the lake's littoral zone in more recent years. Changes to the lake's regulation schedule and strong variations in climate conditions in the past several decades have altered the littoral zone to the extent that habitat conditions in more recent years for both the snail kite and the apple snail have deteriorated. Because the water management capabilities around Lake Okeechobee have not greatly changed since the 1970s, we believe that it is realistic to expect that favorable habitat conditions can again be achieved through water management. Not all of the changes that have occurred since that time were subject to the authorities of the Corps of Engineers. The continued increase in nutrient load to the lake is not within the scope of the regulation schedule, although later in this opinion we discuss the correlation between high water levels and influx of nutrients into the lake's littoral zone, including the critical habitat for the snail kite. Likewise, the spread of exotic and invasive plants is known to be influenced by lake stages, but is not entirely contingent upon the water regulation schedule. Although the lake's regulation schedule is not the only human action having adverse effects on the lake, the Service believes it is a primary determining factor in the observed degradation of littoral zone habitat quality since the 1970s.

There is consensus among researchers that the 1973 vegetation patterns documented by Pesnell and Brown (1977) in the first comprehensive mapping of vegetation in littoral zone were favorable (much more so than in the subsequent decades) to foraging and nesting by snail kites. In order to establish a baseline vegetation condition for the impact analysis for this opinion, we tracked changes in the lake's littoral vegetation from the perspective of snail kite foraging habitat and nesting substrate. We found that snail kite nests were typically adjacent to the larger patches of the most suitable vegetation communities for feeding, and that the kites are less limited by available nesting habitat than they are with foraging habitat. Thus, we chose to analyze the extent of foraging habitat as the measure of incidental take for snail kites. For details on how we used these data for our estimation of incidental take, please refer to the "Amount or Extent of Take" section of this opinion.

To track the long-term trend of suitable snail kite foraging habitat, we categorized the vegetation of the western littoral zone (the approximate extent of the designated critical habitat within Lake Okeechobee) into "optimal", "marginal" and "unsuitable" classes for the years when we have data -- 1973, 1996, and 2003. The vegetation surveys for these three years each used a different vegetation classification system, and due to the limitations of remote sensing technology and survey design, none of them are ideal for conclusively categorizing each plant community type for their quality as snail kite habitat. As an example of how we classified the plant communities, Table 3 shows the classification of the 2003 data into the three habitat quality categories.

Table 3. Classification of 2003 vegetation map codes into categories for snail kite foraging suitability. U=Unsuitable, M=Marginal, O=Optimal.

Plant Community Description	Snail Kite Foraging Suitability
Brazilian pepper (<i>Schinus terebinthifolius</i>)	U
buttonbush (<i>Cephaelanthus occidentalis</i>)	U
buttonbush mix	U
cattail (<i>Typha</i> sp.)	U
cattail mix	M
elephant ear (<i>Colocasia esculenta</i>)	U
emergent mixed often as floating mat	M
floating islands/tussocks with mixed vegetation	U
fragrant water lily (<i>Nymphaea odorata</i>)	M
levee	U
Melaleuca (<i>Melaleuca quinquenervia</i>)	U
mixed forest	U
mixed grass (not torpedo grass)	M
<i>Nymphaea</i> Mix	M
open water	U
open water with mixed vegetation (floating and/or tussocks)	U
permanent disturbed	U
Phragmites (<i>Phragmites australis</i>)	U
Phragmites mix	U
pond apple (<i>Annona glabra</i>)	U
sawgrass (<i>Cladium jamaicense</i>)	U
sawgrass mix	M
spikerush (<i>Eleocharis cellulosa</i>)	O
<i>Thalia</i> mix	U
Torpedo grass (<i>Panicum repens</i>)	U
Torpedo grass mix	U
treated cattail	U
treated Melaleuca	U
willow (<i>Salix caroliniana</i>)	U
willow mix	U

Because the 2003 vegetation survey is the most current data we have available showing the vegetative conditions of Lake Okeechobee's western marshes, we are using that year as our baseline vegetation condition in order to estimate incidental take for the snail kite from future decline in habitat suitability. For details on how we used these data for our estimation of incidental take, please refer to the "Amount or Extent of Take" section of this opinion. The Service will use the most current vegetation data available prior to implementation of the new schedule as the baseline habitat condition. Should new data based on 2006 vegetation conditions become available, the Service would then establish 2006 as the baseline vegetation condition rather than 2003. Although this opinion was prepared in 2007, the 2006 data have not yet been

accepted; a rigorous quality control process is necessary before these data can be considered valid for use.

Figure 9 shows a side-by-side comparison of the three years for which we have accurate vegetation data. The trend of habitat conversion from optimal snail kite foraging habitat to marginal and unsuitable habitat from 1973 to 2003 is severe. Some of the observed changes in habitat quality are likely attributable to differences in classification of the plant communities between the three years. However, the extent of these differences is minor compared to the observed real changes in broad community types, such as the conversion of wet prairie and herbaceous marsh communities to floating leaf slough communities and open water. The increase in high-density herbaceous communities, such as cattail and sawgrass, has also played a significant role in the loss of optimal and marginal quality foraging habitat.

Table 4 and Figure 9 show that the quantity of optimal snail kite foraging habitat had decreased from 1973 to 1996 by almost 20,000 acres, and it dropped over 8,500 additional acres from 1996 to 2003. This change was mainly due to the loss of the spikerush community, with a corresponding increase of denser vegetation including cattails, fragrant water lily and torpedo grass (*Panicum repens*). When 2006 vegetation becomes available for use, those data will be added to this table to document further the trends of kite foraging habitat change in the littoral zone.

Table 4. Change in acreage of snail kite foraging habitat in Lake Okeechobee from 1973 to 2003.

Kite Foraging Habitat (acres)	1973	1996	2003
Optimal	28,722	9,613	1,912
Marginal	2,615	14,792	32,023
Total	33,310	26,401	40,431

This is our estimation of loss of foraging habitat in Lake Okeechobee since the Pesnell and Brown survey of 1973. This change of kite foraging habitat may be due to a number of factors, including climatological events outside of the ability of water managers to accommodate. However, the regulation schedule is one of many factors that affect habitat conditions within the lake. Previous sections of this report discuss such factors, including hurricanes, drought, nutrient loads, and exotic vegetation.

The study team based their assessment and selection of alternatives under consideration on simulations using the South Florida Water Management Model. These simulations include the climate conditions (rainfall and evapotranspiration) for the 36-year period between 1965 and 2000. When comparing alternatives against the "no action" alternative there is a built-in assumption that future climatic conditions will approximate those in the 36-year period of record. Although we know that future water years will not be an exact copy of that simulation period, the intent is to capture enough hydrologic extremes in terms of flood and drought to see how the proposed alternatives are likely to respond, and it is the best available information on which to base the simulations. Therefore, the comparison of simulations covering the 36-year period of record gives an indication of how alternatives may differ in their reaction to several cycles of

extreme climate events and the frequency at which certain key lake stages (both extreme highs and lows) may occur over a period of more than three decades.

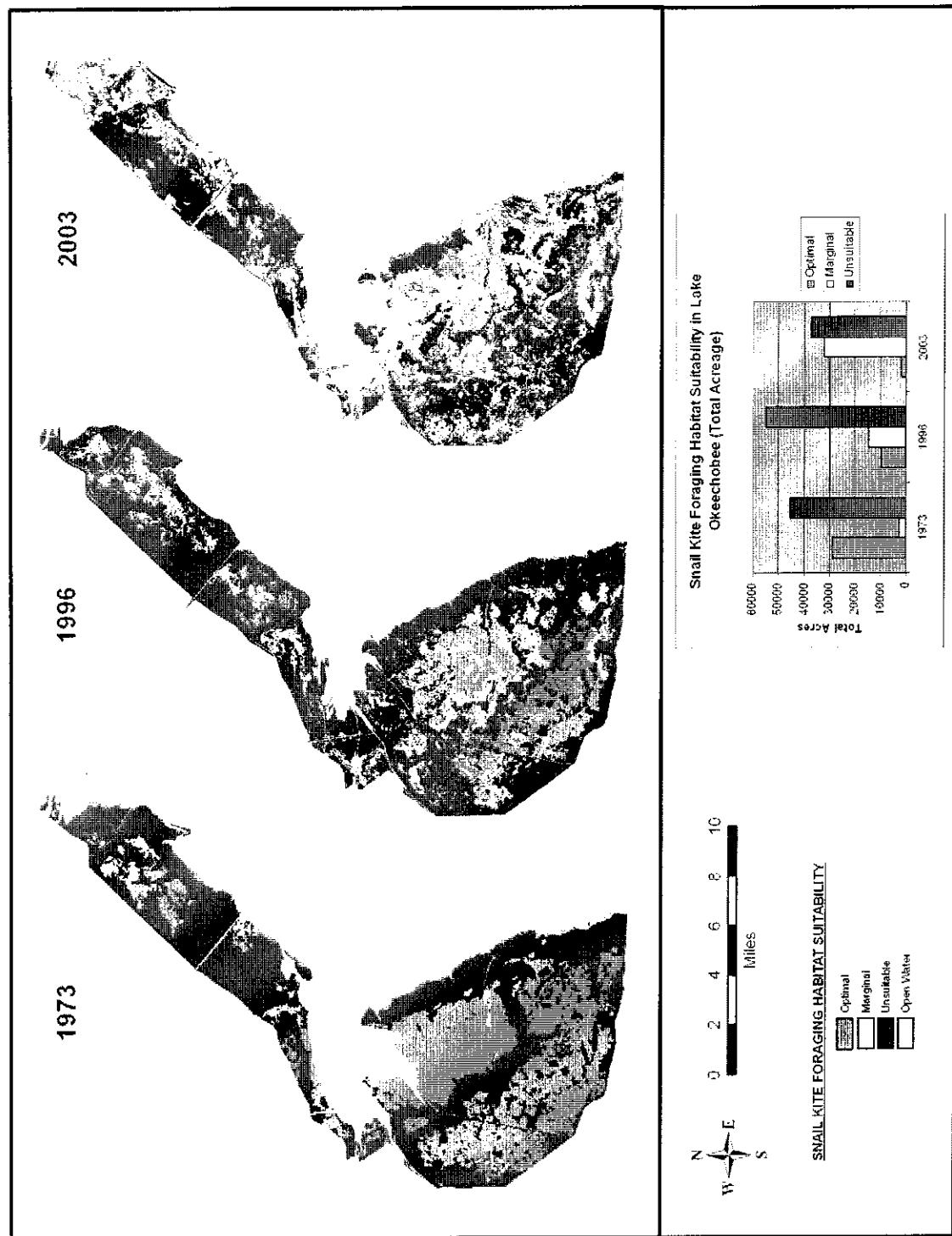


Figure 9. Changes in snail kite foraging habitat in the western marshes of Lake Okeechobee, 1973, 1996, and 2003.

Status of the species within the action area

The action area encompasses the current range of the Everglade snail kite. The following discussion deals with the history of snail kite use of Lake Okeechobee, with a particular emphasis on nest numbers and nesting success. We discuss observations and hypotheses relating water stages to use of Lake Okeechobee as habitat. We refer to other portions of the species' range for comparative purposes. The Service looked closely at performance measures in the WCAs and ENP. The modeling suggests that the potential project effects within these areas are so small as to approach insignificance, often around a one percent difference. We believe that this is partly due to the lack of sensitivity and accuracy of the current model in detecting such small changes, but it is also partly due to practical constraints imposed on all of the evaluated alternatives. Sending water south to the remnant Everglades is strictly limited in the simulations due to the limited capacity to cleanse water through the existing set of treatment marshes. This constraint is imposed so as not to violate the consent decree for water quality in the Everglades Protection Area, which includes the WCAs (Case No. 88-1886-CIV-HOEVELER).

The rapid and extreme fluctuations in water stages in Lake Okeechobee are not within the complete control of human management for two principal reasons. The first is the high variability in rainfall in Florida, which is not subject to human management, but this natural fluctuation is amplified by flood control and water supply management practices on the lake. Secondly, the existing water management infrastructure is unable to handle these extremes, and in many cases may amplify the severity of these events on the ecological integrity of central and south Florida.

Both extreme high and low lake stages adversely affect the ecology of the lake, including the snail kite. While we refer to both in the discussion that follows, the emphasis is more on the impacts of drought. This is because the principal basis for our determination that the Alternative E schedule may have an adverse effect on snail kites rests with its increased risk of drying out the littoral zone of Lake Okeechobee more frequently and more severely than under the preceding WSE schedule. Extreme low water stages are adverse to sustaining abundant apple snail populations in the littoral zone of Lake Okeechobee.

Scientific debate has been vigorous for several decades on the type and degree of effects of drought on the survival and recovery of the snail kite. Earlier researchers, such as Sykes and Beissinger, emphasized the threat of dispersal and mortality of snail kites in response to drought. While subsequent researchers, particularly Bennetts, Kitchens et al. (1998), recognized that drought adversely affects snail kites, they believed that previous estimates of population decline due to drought had been exaggerated by dispersal of many individuals to habitats where they were not detected. For example, the statement by Takekawa and Beissinger (1989) that the 1981 drought reduced the population of snail kites from 650 individuals to about 250 is now considered inaccurate. The Service considers that this was likely not only an underestimation of the total population in those years, but also, and more significantly, not a valid conclusion that the population was reduced by such a dramatic proportion (more than a 61 percent reduction in snail kite numbers between 1980 and 1982). Bennetts, Kitchens et al. (1998) examined the

intensity and geographic extent of historic droughts relative to the snail kite's range. They believed that in less extensive droughts, snail kites would exhibit more of a behavioral response, moving from the more affected habitats to other less severely affected wetlands in their range. In more extensive and severe droughts, they agreed that increased mortality would affect the population of the species as a whole.

Sykes (1983a) reviewed data from annual snail kite counts in the years 1968 through 1980. While these annual counts should not be relied upon as accurate measures of the total population of the species in Florida (Bennetts, Link et al. 1999), the Service considers that the relative proportions of observed birds in various parts of their range are reasonably reliable. Lake Okeechobee and WCA3A were clearly the dominant areas supporting the species among those areas consistently surveyed from year to year (Figure 10).

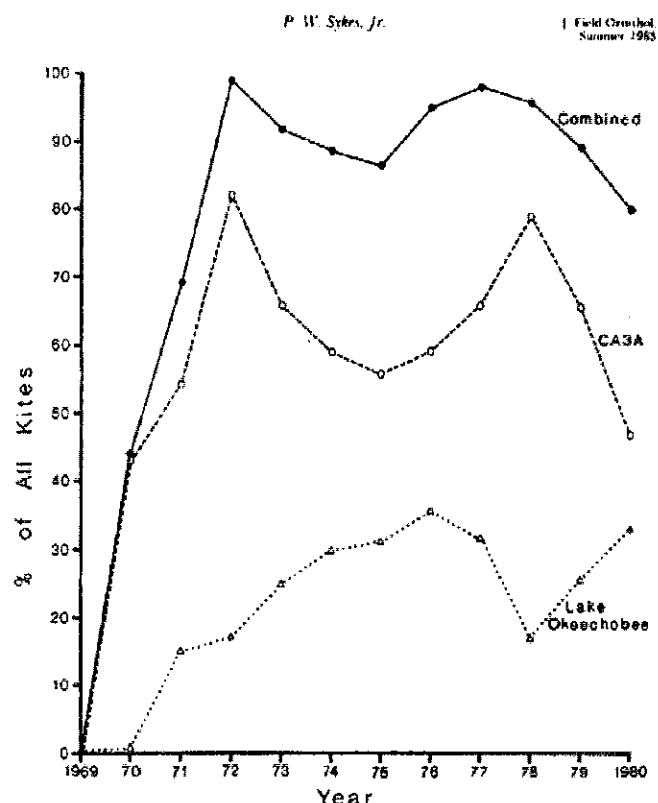


Figure 10. Percentage of snail kites sighted in Lake Okeechobee and WCA3 during mid-winter censuses in the 1970s and 1980s (from Sykes 1983a).

Although these were simply mid-winter bird counts, we know that the species nested successfully in Lake Okeechobee during that period (Sykes 1979). As is typical for this species, he reported that the number of nests and the number of successful nests in Lake Okeechobee were highly variable in the period, with 1975 and 1976 the most productive years. In 1975, he observed 25 nests in Lake Okeechobee, with 13 of these successful; in 1976, 18 of 23 nests were successful. Sykes noted that in the years 1968 through 1971 there was little activity of snail kites in Lake Okeechobee, but this increased greatly in the mid-1970s. By comparison, such numbers

of successful nests have not been recorded from the lake from the late 1990s through 2007 (Figure 11). The levels of productivity observed in 1975, 1976, 1987, 1988, or 1991 through 1993, would be considered good or excellent nesting years for the lake if they occurred today. The Service believes that even under natural conditions prior to human management of water resources in south Florida, nest productivity likely was highly variable from year to year, simply due to natural patterns of drought and flood. However, based on patterns and total productivity in the period from the mid-1970s to the mid-1990s, we believe that the nesting in Lake Okeechobee from 1997 to 2007 has remained low for a long period.

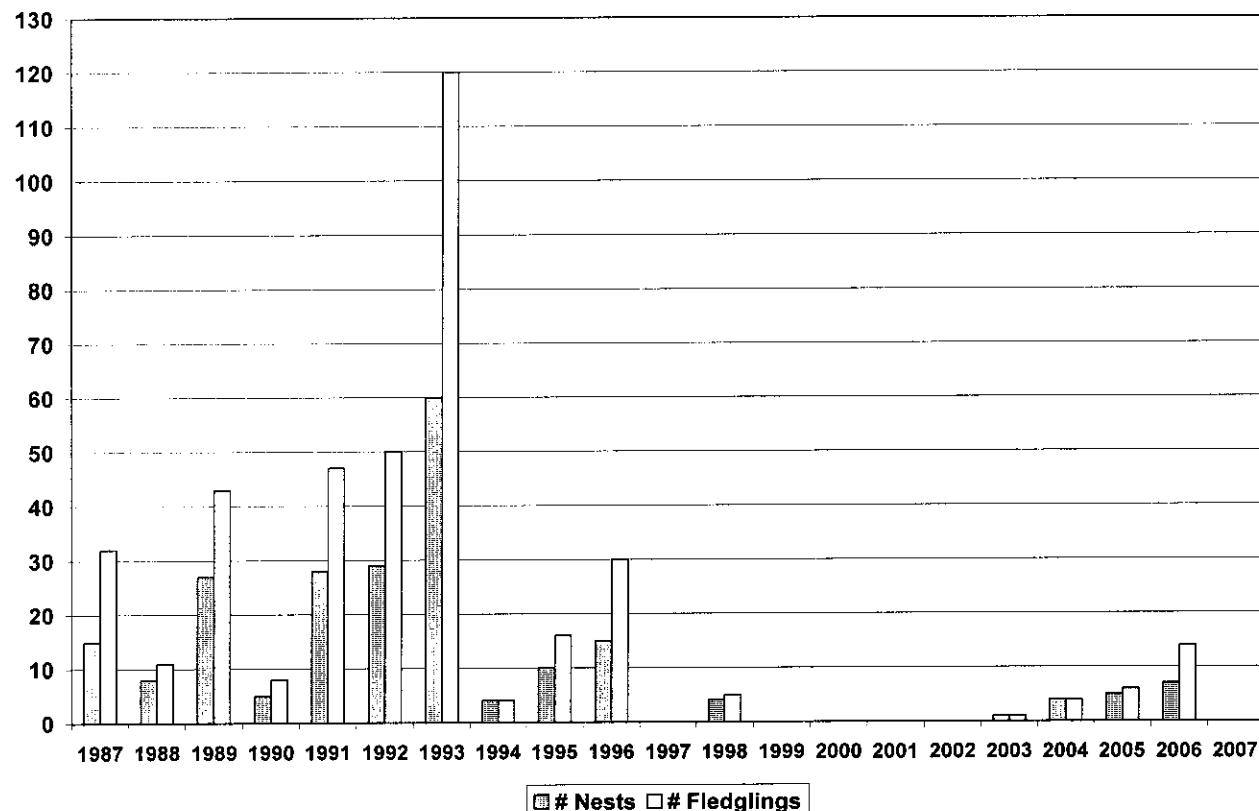


Figure 11. Number of successful nests (fledged at least one bird) and total number of young fledged between the years 1987 and 2007 on Lake Okeechobee.

Beissinger (1981) reported that during the 1981 drought, “by June, nearly all the wetland habitat that kites usually inhabit was dry.” Nesting was extremely limited on Lake Okeechobee, and he estimated that only 14 to 17 percent of the birds attempted to breed and only two of the ten nests fledged young. In that year, he noted that in WCA3, “. . . the stronghold of kites for ten years, all nests failed.” He believed that total recruitment for all areas he surveyed was probably as low as four individuals. Beissinger attributed the adverse conditions for snail kites to a combination of low rainfall, high water consumption demands, and “. . . water management errors that, I believe, included lowering of water levels in fall 1980 by the Corps of Engineers in (false) expectations of hurricane rains.” Beissinger’s 1982 annual report reported some recovery of breeding in the WCAs, but he noted that rains from Tropical Storm Dennis in August 1981 mainly fell south of

Lake Okeechobee. He stated that no successful breeding occurred in southern portions of the species' range that were typically important breeding areas – WCA3A, WCA2B, and Lake Okeechobee. He found modest breeding success in Lakes Kissimmee and Tohopekaliga, in the Kissimmee Chain of Lakes.

While we agree with Beissinger's general observations of reduced nesting success in the drought years of 1981 and 1982, subsequent research (Bennetts and Kitchens 1997; Bennetts, Kitchens et al. 1998) does not support his assertion that "drought conditions would be responsible for decimating two-thirds of the kite population." While subsequent researchers agreed that drought is likely a factor in snail kite mortality, the level of mortality was not known; it would vary with the intensity and geographic extent of drought, and previous estimates of drought-caused mortality were likely inflated. These effects are partly due to differences in detectability of juvenile and adult birds as they scattered more diffusely throughout the species' range (Bennetts, Link et al. 1999).

Beissinger and Takekawa (1983) provide some additional observations of the response of snail kites in Lake Okeechobee to the 1981 drought. They observed that snail kites began to be less abundant in the lake beginning in the winter of 1981. As water levels receded, the remaining birds concentrated in interior portions of the littoral zone, near the mouth of Moonshine Bay, Fisheating Creek, and along the northeastern shore at Horse Island. When water stage reached its lowest levels of that drought in July and August 1981, nearly all of the remaining kites were observed along sections of the Rim Canal near Moore Haven and Clewiston, the mouth of Harney Pond Canal, and along the northwest shore near Little Sarasota boat landing. Lake Okeechobee was an important habitat for the species during the initial stages of the drought, but later in 1981 through 1982, the lake did not continue to be suitable habitat for kites. The 1981-82 drought is one of the most severe on record when looking exclusively at Lake Okeechobee stages. Water stages remained below 11 ft in 1981 for 110 consecutive days. In 1982, lake stage hovered just above and just below 11 ft; in that year, there were 93 non-consecutive days below a stage of 11 ft.

Immediately following the 1981-82 drought, water levels rose sharply during the El Niño winter of 1982-83 to stages that are known to adversely affect habitat in terms of high water. Lake stage remained above 16 ft for a total of 267 days from August 1982 to May 1983. This event was so severe, that it has been called the "Mother of All Los Niños" (Green et al. 1997). While Beissinger (1983) reported that the 1983 nesting season was a successful one for snail kites overall (mainly due to the Kissimmee Chain of Lakes and WCA3), Lake Okeechobee only had "a few unsuccessful attempts." Unfortunately, we do not have nesting success data for Lake Okeechobee in this period, so it is difficult to speculate if there were lingering effects on snail kites in the years following this back-to-back severe drought and subsequent flooding.

Dr. James Rodgers of the FWC surveyed snail kites on Lake Okeechobee and the Kissimmee Chain of Lakes beginning in 1981. In the 1981 through 1986 period, his efforts were largely limited to mid-winter counts. In Rodgers' opinion (1994, 1996) the snail kite recolonized portions of its historic range in the 1980s, including Lake Kissimmee, Lake Tohopekaliga, and East Lake Tohopekaliga, all of which are within the Kissimmee Chain of Lakes. He believes that the lack of observations in those areas in the 1960s and 1970s was due to a contraction in the

species' range, and not simply due to a lack of search effort in those areas north of Lake Okeechobee.

We have geo-referenced nest location and nest success data from Rodgers' studies in Lake Okeechobee from 1987 through 1993. This spans another drought that affected Lake Okeechobee in 1990 to 1991. Again, as is expected for this species, nesting in Lake Okeechobee was highly variable among years. Rodgers (1992, 1994) found that years in which lake stages were at or above 14 ft at the typical beginning of the breeding cycle in February were more successful than in years when the stage was lower in February. He attributed this, in part, to the fact that potentially nesting birds would need to compete for a smaller number of apple snails in low water years, because he estimated that at a lake stage of 14 ft, about 92 to 94 percent of the littoral zone would be flooded. In contrast, at a lake stage of 12.5 ft, he estimated that only about 28 to 30 percent of the littoral zone was inundated.

Rodgers also attributed the differences in nest success to the location of nests in different water years. Under moderately high lake stages in 1987, kites nested both along the outer cattail and bulrush (*Typha* spp. and *Scirpus* spp.) wall, and a portion of the inner littoral marsh centered around Moonshine Bay, which had large areas vegetated with spikerush (*Eleocharis cellulosa*) and beakrush (*Rhynchospora tracyi*). In a year such as 1987, both the inner and outer portions of the littoral zone at that time had sufficient periphyton growth on the emergent vegetation to support apple snail populations, yet were not too dense to preclude the visual foraging technique of the snail kite. The differences in nesting success were not only dependent on the extent of potential foraging habitat with suitable water depths; lake stages also affected the availability of vegetation that more securely supports nests. With moderately higher lake levels in 1987 and 1988, most kites used woody vegetation for nesting; however, herbaceous vegetation supported the vast majority of nests at lower lake stages in 1990 and 1991. Kites prefer woody substrate that is inundated, but they are forced to nest in non-woody species at lower lake levels. Thus, lower lake levels forced kites to nest in less stable nesting substrates (e.g., cattail and bulrush). In the moderately high water years of 1987 and 1988, 55 percent and 89 percent, respectively, of the nests were placed in woody vegetation, mainly willow (*Salix caroliniana*), melaleuca (*Melaleuca quinquenervia*), or buttonbush (*Cephalanthus occidentalis*). These woody shrubs or trees provide a more stable substrate that is less vulnerable to collapse. In contrast, in the lower water years of 1990 and 1991, 100 percent and 79 percent of the nests, respectively, were placed in herbaceous vegetation, primarily cattail and bulrush. The overall nesting success (fledged at least one juvenile) was 22 percent in 1987, 42 percent in 1988, 18 percent in 1990, and 18 percent in 1991 (Rodgers 1992, 2007). Although the presence and availability of preferred nesting structure is important, we believe that the availability of apple snails is a relatively more limiting factor in describing suitable snail kite habitat.

Figure 12 illustrates the locations of nests in 1987, 1988, 1990, and 1991 on top of the bathymetry for the lake, alongside graphs of the lake stages for the first 6 months of those years (when most snail kite nesting would occur). Notice that in the moderately high water years of 1987 and 1988, several nests were located at higher elevations of the inner portion of the western littoral zone of the lake, including the area fringing Moonshine Bay. This area is more likely to sustain pockets of shrubby vegetation, allowing nest site selection in woody vegetation, while

also allowing adequate foraging opportunities in less dense marshes. In contrast, the 1990 and 1991 nest locations on Figure 12 show that in the low water years, the majority of the nests were located along the outer fringe of the littoral zone, on the side of Observation Shoal facing the center of the lake, in an area at that time was dominated by bulrush. Although nests in the bulrush are less securely supported and are more exposed to wind and waves, the presence of this habitat at least allowed some successful nesting in lower water years.

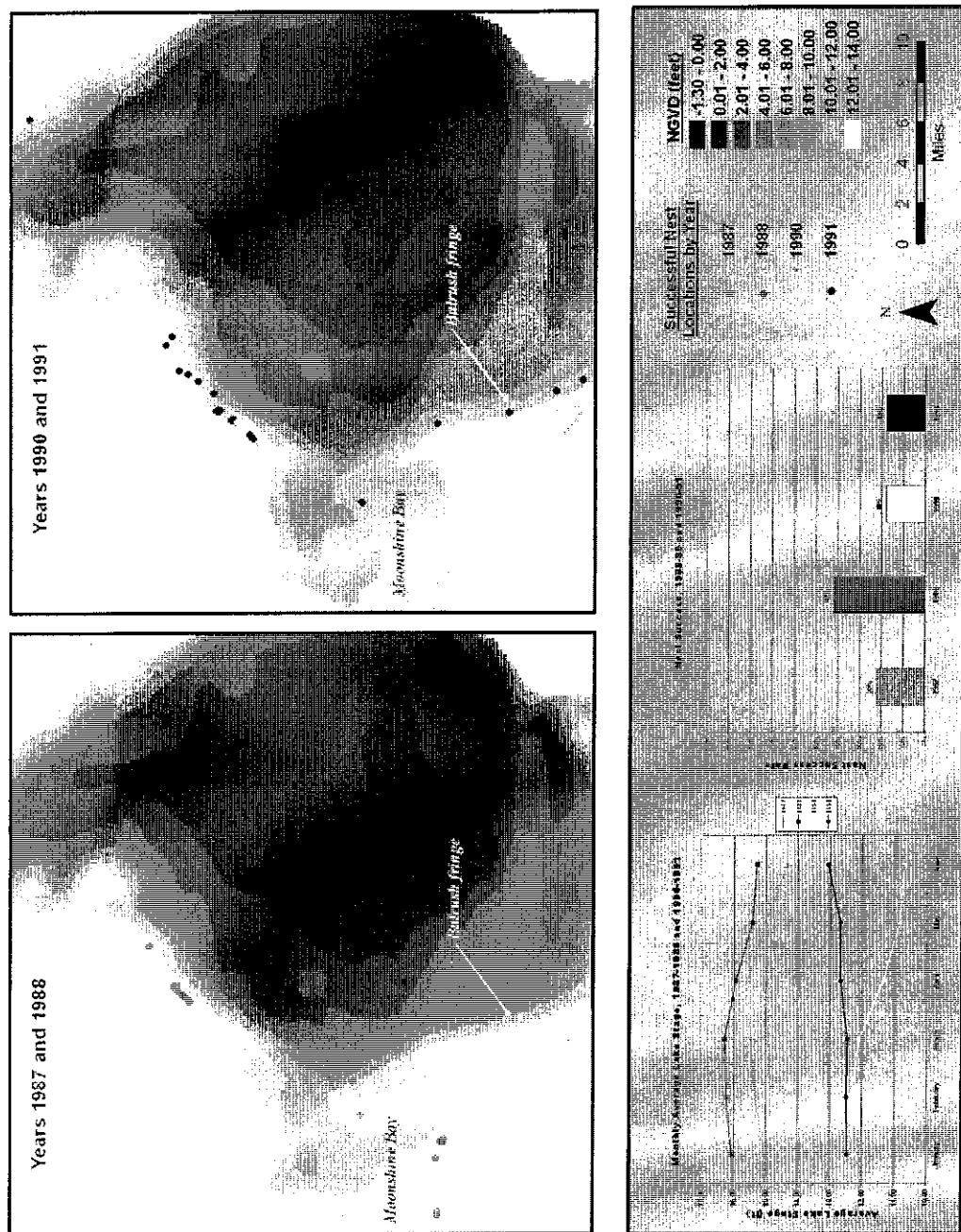


Figure 12. Location and success of Everglade snail kite nests on Lake Okeechobee in two high water years (1987 and 1988) and two low water years (1990 and 1991).

The conclusion we draw from the above analysis and the number of successful nests in 1991 (please refer back to Figure 11) is that, given otherwise favorable habitat conditions, snail kite nesting may be only temporarily disrupted in the lake following a moderately severe drought, similar to what occurred in 1990. At the low point of the drought between May and July of 1990, the stage dropped below 11 ft for 70 days. Although there were relatively fewer successful nests that year, snail kites were able to fledge 8 juveniles from 5 successful nests. This indicates that sufficient apple snails persisted on the outer fringe of the marsh in 1990. This strongly suggests that the snail kite can be somewhat resilient to a drought of the magnitude observed in 1990, if the outer fringe of Lake Okeechobee's littoral zone is present and supports apple snails. In more severe droughts, such as 2001 and 2007, snail kites are unable to nest at all in Lake Okeechobee. The snail kite population can only then be resilient by shifting nesting activity to other portions of its range. In 2007, we believe that although overall reproductive success will be diminished, increased nesting activity in the Kissimmee Chain of Lakes can only partially compensate for the absence of nesting habitat in Lake Okeechobee. We will await data on how severe the impact of the 2007 drought will be in terms of total population estimates and the return of successful nesting to Lake Okeechobee in subsequent years.

Bennetts and Kitchens (1997) emphasized the concept of a habitat network (Figure 13) in conservation strategies for the snail kite. Their publication did not specifically mention Lake Okeechobee, but their conceptual diagram of the habitat network illustrates that the lake is central to the range of the species, and the relatively larger circles drawn for Lake Okeechobee and WCA3 generally symbolize the importance of these two major wetlands as habitat. They pointed out that water managers should not necessarily attempt to maintain any particular wetland inundated throughout natural drought cycles, and believed that adverse impacts on vegetation patterns in marshes sustaining snail kites might begin after 5 years of continuous inundation. They also indicated that droughts differ in both their spatial distribution across the species' range, and in their intensity in each of the major wetland units used by the kites. They believed that less intense or less widespread droughts were more likely to cause a behavioral response (movement of individuals to other habitats), while droughts that are more widespread would likely cause mortality of individuals, with a resulting change in demography of the population. They also note that due to the mobility of the species and the inability to track the movements and survival of individuals throughout the species' range, the relative impact of these two responses had been confounded in previous publications and would continue to be difficult to accurately separate.

Martin, Kitchens et al. (2006) recognized that long-distance movements of snail kites are documented; however, their more recent research discusses the limitations of the habitat network of Bennetts and Kitchens (1997). Martin, Nichols et al. (2006) recognized several major non-contiguous regions within the range of the snail kite (Kissimmee Chain of Lakes, Loxahatchee Slough, Lake Okeechobee, St. Johns Marsh and the Everglades). The latter publication used empirical data on kite movements in an estimation of effects on the snail kite population, correlated with hydrology data for the period from 1992 to 2003. The analysis indicated that snail kites were more likely to move among "contiguous" or "moderately isolated" wetlands within each of these regions than between more "isolated" regions. Lake Okeechobee is

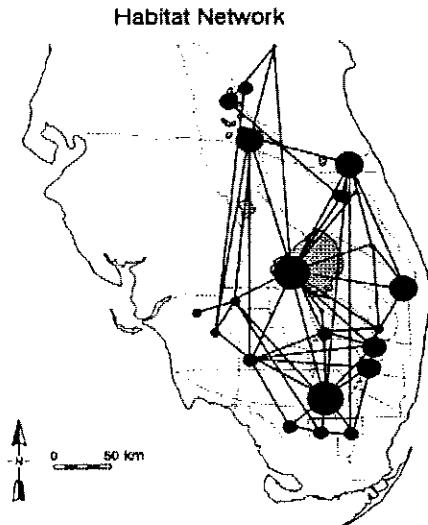


Figure 13. The network of habitats in central and south Florida derived from telemetry of snail kite movements (from Bennetts and Kitchens 1997).

considered to be an isolated region within their model. They found that for the 2001 drought, “Only a small proportion of kites escaped a regional drought by moving to refugia (wetlands less affected by drought). Many individuals died after the drought. During drought adult survival dropped by 16 percent while juvenile survival dropped by 86 percent (possibly because juveniles were less likely to reach refugia).” There should be an opportunity to compare the effects of the 2007 drought on snail kite movements among different regions, and on the estimated mortality of juveniles and adults, in relation to the hypotheses tested in the analysis for the 2001 drought.

Dreitz et al. (2001) performed an analysis of nesting success and water levels spanning 22 years of data and 11 wetlands throughout the species’ range. They concluded that mean annual minimum water elevation was not a reliable predictor of the proportion of nests that are successful.

Beissinger and Snyder (2002) criticized the analysis of Dreitz et al. (2001). They stated that the effects of low water on nesting success should be analyzed separately in each of the major “wetland units” (e.g., Lake Okeechobee, WCA 3A) used by snail kites in Florida. As an example, they cite observations of different responses of snail kites in selecting nesting substrate in lakes than in the WCAs. They note that in the Kissimmee Chain of Lakes and Lake Okeechobee, kites tend to nest in herbaceous vegetation (mainly cattails), during low water conditions, and they have lower chances of successfully fledging offspring as compared to nesting attempts in shrubs such as willow. They attribute the lesser importance of this aspect of snail kite biology in the WCAs to the availability of patches of woody vegetation over a wider range of water levels. They found significant correlations between water levels and nesting success at individual “wetland units” in the snail kites range, even in non-drought conditions.

While much of this portion of our biological opinion has focused on the effects of drought, extremely high rainfall totals in 1994-1995 appear to have affected the ecology of Lake Okeechobee severely and for a prolonged period. Lake stages exceeded 16 ft for 216 consecutive days between September 1994 and April 1995. While stages briefly dropped below 16 ft in the spring of 1995, they again stayed above 16 ft for 183 consecutive days between August 1995 and February 1996. Referring back to Figure 11, 1995 and 1996 were moderately successful nesting years for the snail kite. However, from 1997 through 2003, there was close to no successful nesting by snail kites on the lake. We have noted that fluctuations in snail kite use of particular wetlands in their range are to be expected. However, this extended period of low to no nesting is alarming because it is prolonged, and because Lake Okeechobee is one of the largest expanses of potential habitat in the species' range. Lake Okeechobee was, along with WCA 3, historically one of the most consistently used and productive habitats. Figure 14 shows that the proportion of young banded and detected in Lake Okeechobee has been low for more than a decade. This is in contrast to previous decades, when Lake Okeechobee and WCA3 were the main habitats for the species; in recent years the Kissimmee Chain of Lakes has produced more juvenile kites than Lake Okeechobee.

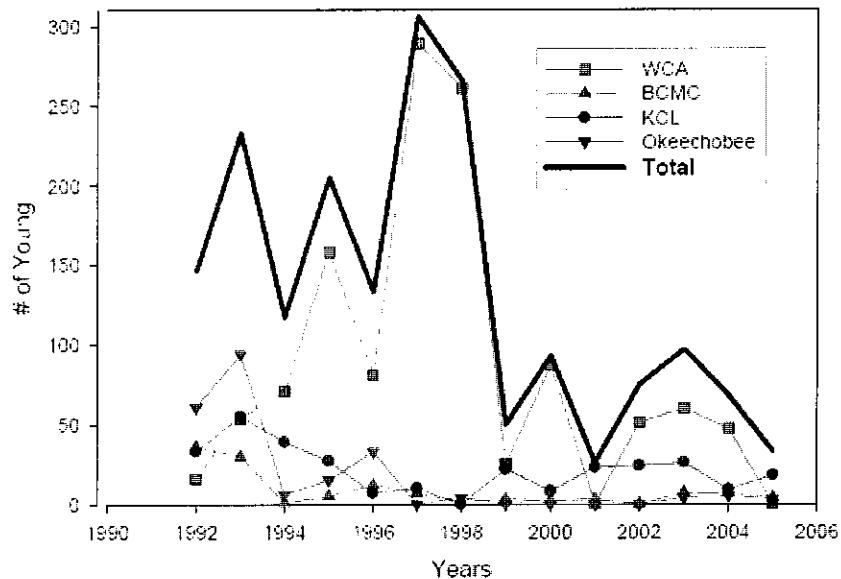


Figure 14. Number of young detected and banded in the BCMC, WCAs, Kissimmee Chain of Lakes (KCL), Lake Okeechobee, and all areas combined (total), between 1992 and 2005 (from Martin, Kitchens et al. 2006).

While we cannot attribute a single cause to this decline in habitat use in Lake Okeechobee, we must note that during the lengthy 1994-1995 high water years, significant amounts of vegetation were torn away from the littoral zone. The most notable effect was the nearly complete loss of the outer fringe of the marsh that had been dominated by bulrush and that appears to have been crucial in sustaining snail kite nesting through the 1990-1991 drought. Loss of the bulrush "wall" along Observation Shoal also exposed inner portions of the littoral zone to wave damage.

Little recovery of the bulrush fringe was noted prior to the severe drought of 2001, when lake stage dropped to a record low of 8.97 ft on May 23, 2001. Lakes stage fell below 11 feet for 74 days, which is a similar duration to the 1990 drought. We are uncertain as to why there was no lag in use of the lake by snail kites following the 1990 drought, yet snail kites did not return to use Lake Okeechobee for several years following the 2001 drought. Certain aspects of the 2001 drought were beneficial to the lake's ecology overall; following the drought, lake stage rebounded quickly to a favorable level, which allowed submerged aquatic vegetation to recover in the lake. However, we caution against statements that would generalize from the experience of the 2001 to imply that the lake should be intentionally lowered on a frequent basis. There are many confounding factors, including the timing of the drying, the time since the last drying, and the stage to which the lake returns following the drought. Unlike the moderately severe drought of 1990, the 2001 drought appears to have set back recovery of the apple snail population for several subsequent years in Lake Okeechobee. Figure 8 shows that adult survival dropped range-wide for the snail kite from 2001 to 2002, which is likely attributable to the 2001 drought. Juvenile survival rates are typically highly variable relative to adult survival, and although drought conditions are one of many variables that may affect juvenile survival, the full extent of this effect is unknown.

Following the lag in recuperating apple snail density in the lake, slow recovery of habitat suitability allowed some increases in nesting in the years 2003 to 2006. This gradual increase in nesting occurred despite the disruptive effects of hurricanes that passed over or near Lake Okeechobee in 2004 and 2005. The immediate impact of the hurricanes caused loss of vegetation from the littoral zone, and they also caused persistent suspension of extremely fine sediments that reduced light penetration into the water. Because apple snails feed on periphyton growing on submerged stems, the reduced water clarity likely limited the abundance of apple snails in the lake, which in turn would limit snail kite nesting in the lake. However, there was not consistent monitoring of apple snail densities in the littoral zone in that period.

Figure 7 provides an estimate of total population size for the snail kite throughout central and south Florida. This suggests a decline in the population between 1999 and 2003, with the population estimate remaining relatively stable since then. However, the low nesting success in recent years, coupled with the drop in adult survival during the 2001 drought, is of concern in sustaining the overall population. Although it is clear that the 2001 drought has played a role in the population decline since 2001, the extent to which it is responsible for the currently low number of kites is unknown. At this writing in the spring of 2007, the lake is again experiencing a severe drought. We wait to see in subsequent years if the prey base for the snail kite in the lake will take several years to recover from the current drought.

Several biologists with field experience in Lake Okeechobee have suggested to the Service that snail kites have nested in recent years at higher elevations in the western littoral zone of the lake than in previous periods. We investigated this theory, and we present the data graphically in Figure 13. The 1987 to 1991 period covers the years from which we have reliable nest locations to the change from the 1978 regulation schedule to the Run25 regulation schedule. The 1992 to 1999 period corresponds to use of the Run25 schedule, excluding 1994 and 1995, when we have data on nest success, but no nest location data. The 2000 to 2006 period corresponds to

implementation of the WSE regulation schedule. For 83 successful nests in the 1987-1991 period, the mean lake bottom elevation below the nests was 11.73 ± 0.79 standard deviation (SD). For the 1992-1993 and 1996-1999 period, the mean lake bottom elevation was 12.65 ± 0.53 SD, for 109 nests. In the 2000-2006 period, with locations for only 15 successful nests, the mean bottom contour was very close to the previous period, at 12.74 ± 0.77 SD. Our analysis confirms the perception that prior to 1991 nesting occurred, on average roughly 1 ft lower in the littoral zone than in the more recent time. (Please note that the total number of nests in this analysis do not necessarily correspond with the totals in Figure 11, because we do not have location information for all of the nests.) Figure 15 illustrates that lower portions of Moonshine Bay and the outer fringe of the bulrush zone were used during that period. The Service believes that with a lowered average lake stage with the Alternative E regulation schedule, apple snails and nesting snail kites may be able to gradually shift their activity to lower portions of the marsh, if suitable vegetative structure is present in those areas to support both species. It should be noted that apple snails are unable to survive rapid drying of their habitat, and because they reproduce annually, the population of apple snails can be temporarily extirpated from a wetland. Apple snails do not effectively migrate to seek water in any single year during drying events; we refer above to a potential gradual shifting of their population over several generations in response to a change in mean water levels. Re-establishment of the bulrush fringe, with associated periphyton, along the outer edge of the western littoral zone of the lake would be necessary to allow for this flexibility in response by apple snails and snail kites.

Figure 15 supports the theory, expressed by biologists who have observed field conditions for several years in Lake Okeechobee, that while the proposed Alternative E schedule lowers the average water elevation of Lake Okeechobee about 1 foot relative to WSE, snail kites should be able to gradually adjust the average elevation of their principal foraging and nesting areas back to elevations favored in previous decades. This resilience in the response of snail kites would be further supported if management agencies were able to re-establish the bulrush fringe along the outer edge of the littoral zone. The vulnerability of the bulrush fringe to future high water events will be a combination of several factors, including the maximum lake stage, the duration of moderately high lake stages, and the strength, duration, and direction of high winds while lake stage is high. The Service believes that the series of both high and low extremes in the lake (and active hurricane seasons over the lake in 2004 and 2005) have collectively diminished the habitat suitability in Lake Okeechobee. Yet we must point out that the beginning of the period of low nesting numbers since 1996 coincides with the erosion of the bulrush fringe following the 1994-1995 El Niño (high water) event. While this form of disruption (particularly from hurricanes) is rather unpredictable, the degree of vulnerability is expected to diminish with the proposed schedule, which lowers average lake stage by about 1 foot.

Factors affecting species environment within the action area

Operation of the C&SF Project and other hydrologic management has a significant effect on hydrologic conditions within most of the areas occupied by snail kites. The Corps, District, and St. John's River Water Management District manage water levels in snail kite habitat in accord with many different local and regional water management plans and schedules. The Service has conducted formal consultation on the MWD Program, the IOP, Lake Kissimmee and Lake

Tohopekaliga drawdowns, and several other projects that have affected snail kites and their habitat. Water management plans affect water levels in marshes and lakes upon which snail kites rely, the rates of water level recessions in lakes and marshes, and the timing of high and low water events. These factors directly affect snail kite habitat suitability. The compartmentalization of the Everglades' wetlands under the C&SF Project, and subsequent hydrologic management of each of the compartments has reduced the connectivity of the wetland system upon which kites rely. Separate and independent management regimes for the different compartments have also impacted snail kites in some cases by allowing unfavorable conditions in adjacent wetland units at the same time.

Changes in kite foraging habitat that have resulted from hydrologic management have occurred within the littoral zone of Lake Okeechobee. In this area, prolonged deep water has caused changes in vegetation that affect kites' ability to forage, and prolonged periods of high and low water have impacted the apple snail populations that the kites rely upon for food. They have also affected growth and survival of woody plants that kites use as perches. These changes represent a reduction in the quality of foraging habitat for snail kites, and a reduction in the suitability of habitat to support abundant apple snails. The habitat changes, however, may be reversible by restoring favorable hydrological conditions to the lake's littoral zone, such as lowering water levels to some degree.

Low Lake Stages

Drydowns result from hydrologic management, including both intentional drawdowns to aid in habitat restoration, and drydowns that result from a combination of water management activities and unexpected environmental conditions, such as the 2000-2001 drawdown and drought. In the extreme, these can reduce apple snail populations. Extremely low lake levels (<11 ft) expose 95 percent of the littoral zone to desiccation, rendering the majority of the area unavailable as habitat, including marshes dominated by spikerush. This community is of particular concern because it supports a large population of apple snails. Spikerush is particularly valuable habitat for foraging snail kites because its moderate stem density accommodates the kite's visual hunting behavior. Maintaining clear water, sandy-bottom littoral habitat with emergent vegetation is necessary to support a healthy apple snail population (Darby et al. 2004).

The apple snail is not a very mobile creature. Unlike some other aquatic animal species, apple snails will not move extensively to follow the optimal water conditions that will vary with season and year (Darby et al. 2002). When a portion of the littoral zone inhabited by apple snails dries out because of lowering lake stage, the snails will imbed in the surface layer of detritus, and await the return of the water. After a period of time, the snails will die if the area remains dry. According to Darby (2006), adult apple snails show the following desiccation tolerances: a 3-month dry-out will kill 21 percent of the population; a 4-month dry-out will kill 50 percent of the population; and a 4.5-month dry-out will kill 63 percent of the population. Juvenile snails have even less tolerance to desiccation. For example, a 3-month dry-out will kill 40 percent a population of six-week old apple snails (10-15 mm in size). Considering that apple snails only live for a year to 18 months, it's easy to see how littoral zone dry out could adversely affect a lake's entire apple snail population especially if it occurs during snail breeding season (peak

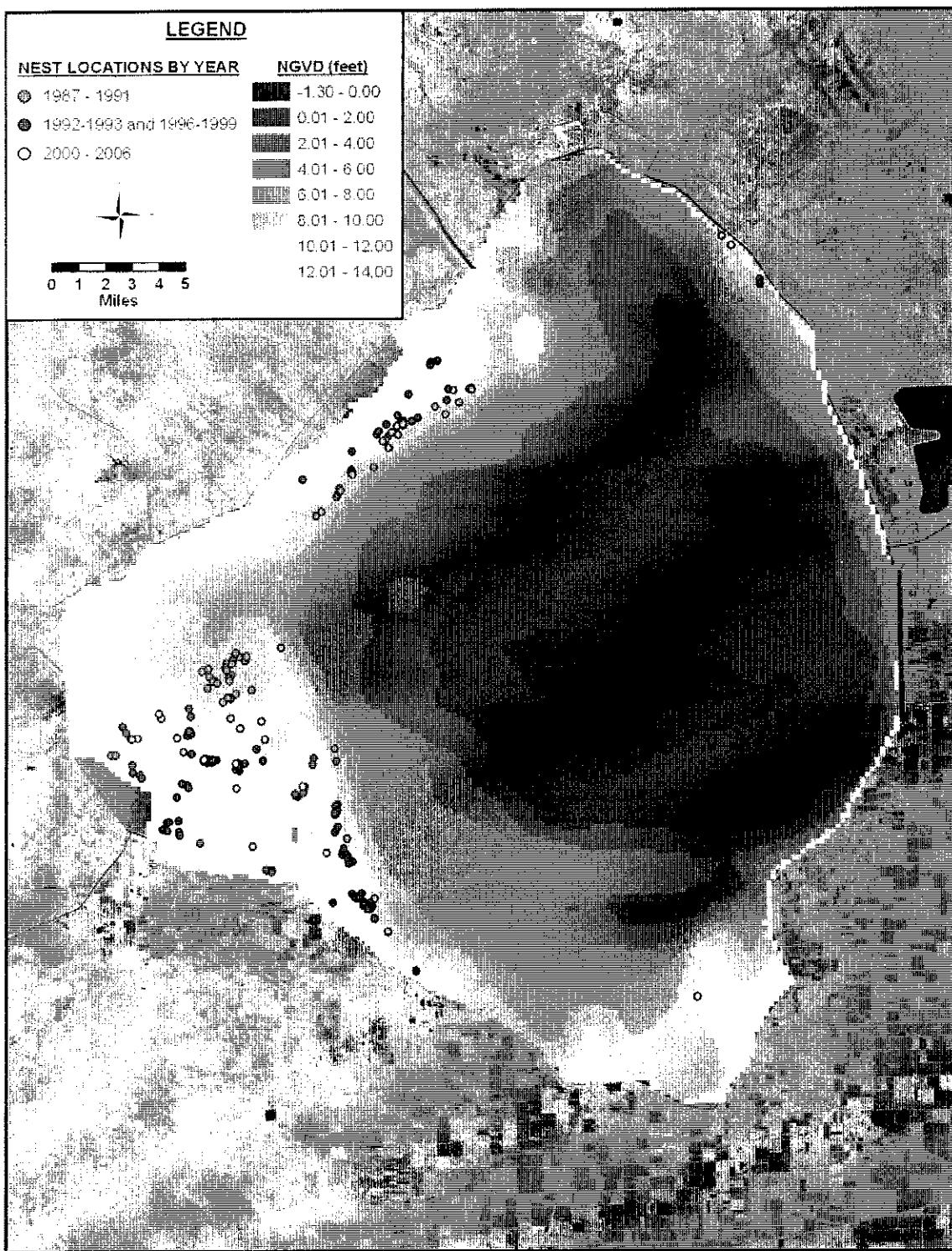


Figure 15. Locations of successful snail kite nests in Lake Okeechobee in three time periods. Background is bathymetry.

production is April to June). Therefore, when discussing the drying of the littoral zone, it is important to keep in mind not only how dry (i.e., how low the water gets), but even more importantly, for how long and at what time of the year.

High Lake Stages

Extreme high water levels (>15.0 ft) are also destructive to snail habitat. Once the water depth in a particular area exceeds approximately 16 inches, the area is considered too deep to allow snails to breed (Darby et al. 2005). Higher lake stages also allow wind storms to tear out emergent vegetation, particularly along the outer edge of the littoral zone. Because the snails must breathe air, they need stems to climb to survive; they also need portions of the stems to remain above water level for their eggs to hatch. When the extremely high lake stages are regularly interspersed with extremely low lake stages, apple snails have no opportunity to recover their numbers. Alternative E increases the extent of the littoral zone that dries out during each low water event, and increases the amount of time that the littoral zone remains dry, thereby potentially increasing the mortality of apple snails in some areas. However, it also decreases the maximum water depth and number of times that the littoral zone becomes too deep to support breeding snails.

High stages will indirectly affect snail kites by reducing the abundance, growth, and reproduction of apple snails. High water levels result in reduced growth rates of young snails and fewer adult-size snails are available for snail kites (Darby et al. 2005). If the apple snail population becomes depressed, it may require several years of favorable environmental conditions to recover.

Recessions

Rapid recessions can be detrimental to snail reproduction when an area dries shortly after snails lay eggs. Newly hatched young snails are not able to survive long periods with water levels below ground. Rapid recession in spring months may result in reduced snail recruitment, and more stranded adult snails that will be unavailable to kite, consequently reducing snail kite foraging suitability.

Long-term Effects of Hydrology on Vegetation

Milleson (1987) documented vegetation changes along the Moore Haven and Indian Prairie transects in the littoral zone, as compared with conditions found by Pesnell and Brown (1977). Milleson found a loss of spikerush, an expansion of cattail, and invasion by the exotic torpedo grass. Torpedo grass is poor habitat and cannot support the fish and wildlife populations that are found in native vegetation. Milleson attributed these changes to prolonged inundation of the littoral zone by stages over 15 ft with the 15.5-17.5 ft regulation schedule, which had then been in effect since 1978.

Hydrologic management also has resulted in impacts to kite nesting habitat. Prolonged deep water within marsh habitats occupied by kites, such as those that have occurred within WCA-3A and within Lake Okeechobee in the last 20 to 30 years, may kill and limit regrowth of woody vegetation that kites use as nesting substrate particularly in the near term. Drawdowns within lake systems may also reduce suitability of nesting substrates.

Water Quality

Degradation of water quality, particularly runoff of phosphorus from agricultural and urban sources, is another factor affecting snail kite habitats. The concentration of total phosphorus in the lake nearly doubled from 49 parts per billion (ppb) in 1973 to 98 ppb in 1984 (Janus et al. 1990). Despite progress in reducing phosphorus loading rates to the lake through implementation of Best Management Practices in dairies north of the lake, the phosphorus loading exceeds the legally-mandated Surface Water Improvement and Management plan target. The Lake Okeechobee Protection Act provides substantial cost sharing incentives to farmers within the Kissimmee basin, and since 2002, many water quality improvement projects have been implemented within the Lake Okeechobee watershed.

Havens and Gawlik (2005) describe in a conceptual ecological model the influence of the decline of water quality in Lake Okeechobee, in conjunction with other ecological stressors on the lake (including water management actions that amplify extreme high and low water events). They note that eutrophication of the lake has wide-ranging adverse impacts, favoring the unnaturally dense growth of nuisance or exotic species of emergent macrophytes, such as torpedo grass, cattail, and water lily; and these have displaced the more favorable littoral zone habitats that were once dominated by moderately dense growth of species such as beakrush, spikerush, sawgrass, and willow. Higher concentrations of phosphorus also promote blooms of cyanobacteria. Eutrophic lakes also exhibit a shift to a less diverse assemblage of nutrient-tolerant benthic invertebrates, which in turn has adverse effects on fish and other animals. The changes in species composition and density of vegetation have adversely affected foraging conditions and nesting substrate for wading birds and the snail kite.

The phosphorus concentration goal for the lake water column is 40 ppb. At present, the concentration of phosphorus in the lake is 214 ppb, with an average of 158 ppb over the past five years (District 2006a), partly due to the high inputs from lake sediments, but mostly from re-suspension of lake sediment from the hurricanes in 2004 and 2005 that has yet to settle out. Figure 16 shows the range in mean total phosphorus concentrations in Lake Okeechobee in 2006; all of these values exceed the target concentration and all except for one month exceed the average concentration of 98 ppb in 1984 (Janus et al. 1990). Even with reduction of phosphorus loading from external sources, internal phosphorus loading from re-suspension of phosphorus-rich sediments that have built up in the lake may affect water quality in the lake for several decades (Havens et al. 1996; Steinman et al. 1998). The result from the four hurricanes in 2004 was a total volume of inflows and rainfall to the lake for the 3 months (August–October 2004) of 3.2 million acre-feet, which is close to an average water year in total volume inflow. This large inflow resulted in high loads of phosphorus, with about 792 metric tons of phosphorus added in these 3 months alone (District 2006b).

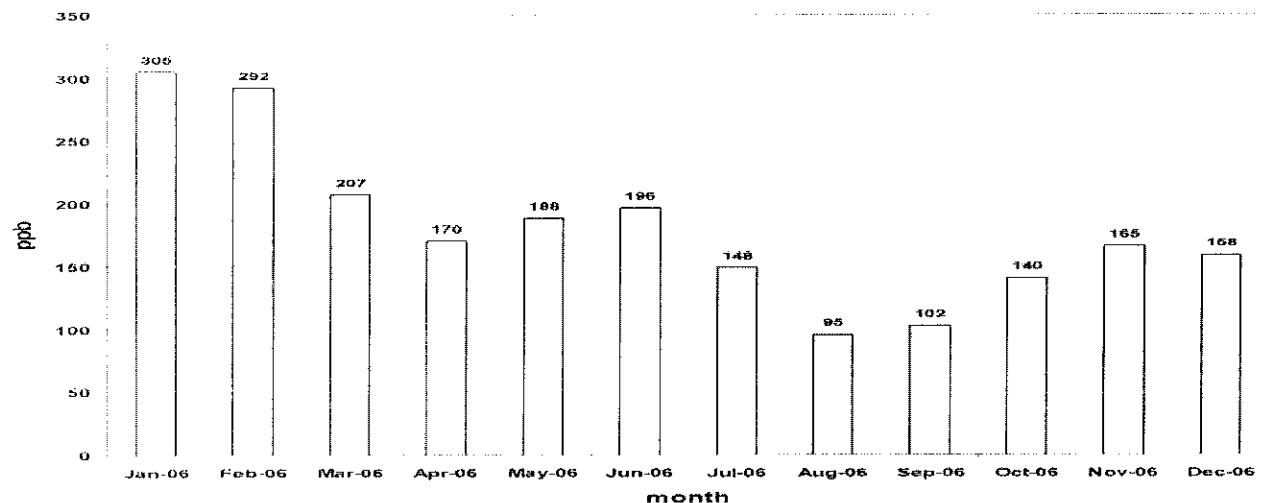


Figure 16. Mean monthly total phosphorus concentrations (parts per billion) in Lake Okeechobee in 2006 (District 2006a).

The District is attempting to address the increased input of phosphorus loads to the lake from northern tributary basins through the Lake Okeechobee Protection Act, which requires the use of agricultural Best Management Practices and other conservation measures. Although the Corps is not responsible for regulation of nutrient loading in the basin, high lake stages have an important influence on the migration of nutrients into the littoral zone from the central portion of the lake.

Exotic and Invasive Vegetation

Exotic and invasive aquatic plants have had an impact on snail kite habitat within the lake systems and other areas. Species such as water hyacinth and water lettuce can grow rapidly within lake littoral zones, completely obscuring areas where kites forage, and can even affect littoral zone vegetation composition and cover by shading other species, changing the water temperature, and competing for space. Dense mats of these species make an area unsuitable for kite foraging. *Hydrilla* (*Hydrilla verticillata*), for example, is a submerged aquatic invasive that has become the dominant submerged species in some lakes. In some cases, hydrilla has resulted in reduced apple snail densities. However, apple snails sometimes occur within hydrilla in high densities. Hydrilla infestations may cause changes in submerged plant species that will affect the abundance, sustainability, and availability of apple snails.

Application of herbicides or mechanical removal are routine maintenance activities conducted by the Corps, the Florida Department of Environmental Protection, the District, the FWC, and other local government agencies to control growth of either invasive exotic species or native species that form dense stands. Controlling invasive plant species is considered to be beneficial overall to snail kite habitat, but depending on how, where, and when these activities take place, these actions can also have some adverse impacts on snail kites. The management objectives of these actions can vary, ranging from the need to keep navigational channels free of dense vegetation, the need to prevent clogging of flood control structures, and the application of herbicides as a habitat management tool. The first two objectives are concentrated on floating plants such as water hyacinth and water lettuce. The latter objective includes treatment of *Hydrilla*, spraying of

floating tussocks that form in lakes, treatment of monotypic stands of the native cattail or the exotic torpedo grass, and treatment of dense stands of other rapidly and densely growing native species, such as pickerelweed. Although the Service agrees that some level of aquatic plant management is necessary and can be beneficial to snail kite habitat in the long term, there are two types of potential adverse effects on habitat for the snail kite. The first is direct disturbance or destruction of snail kite nests; although this is a short-term direct impact, anything that may disturb reproduction of this species can have longer-term consequences on its population. To minimize this impact, the Service, in recent years, has disseminated among these agencies the locations of active snail kite nests so they can avoid actions close to nests. The second type of impact involves the effects of the various aquatic plant management programs on non-target species, the implications of various management prescriptions for multiple objectives (navigation, flood control, water quality, fisheries habitat, and waterfowl habitat to name a few), and how compatible the resulting vegetative composition, density, and structure will be as snail kite habitat.

Fire Management

Fire management within the marshes and some of the lakes affects snail kite habitat. Prescribed burning conducted by FWC, District, ENP, and other agencies can cause changes in snail kite nesting and foraging habitat. While most areas of snail kite foraging habitat are not likely to burn due to low density of vegetation, these areas may burn during drought conditions and dense patches of vegetation within foraging habitat may burn under normal conditions. Vegetation generally regrows rapidly following fires in marsh communities. Because kites rely on visual detection of prey, reduction in vegetation density may improve kites' ability to forage successfully. However, fires may damage or kill woody plant species that provide nesting substrate.

Rodgers (1989) noted the beneficial effects of a controlled burn in the northwestern portion of the littoral zone (Buckhead Ridge to Harney Pond Canal). He considered that this burn was part of an effective management tool to reduce the expansion of torpedo grass and promote recovery of the more favorable spikerush community. In the 2001 drought, management agencies used a combination of burns and herbicide applications to hinder the expansion of torpedo grass and to reduce the overly dense vegetation in the marsh. Because these management actions require an extremely low lake stage, the Service does not support such actions more frequently than once every 8 to 10 years.

Recreation

Recreational activities directly affect the suitability of kite habitat. Boat and airboat traffic throughout snail kite habitat has caused some local vegetation changes, and can temporarily affect the suitability of kite foraging habitat. In addition, these activities may result in disturbance to kites. Although the Service has no control over the operation of private watercraft, we believe that all federal and state watercraft should abide by recommended buffer zones that would minimize disturbance to nesting kites and other waterbirds (Rodgers and Schwickert 2003; Service 2006).

Critical Habitat (Environmental Baseline)

This section has focused on the species status within Lake Okeechobee, the area most affected by the proposed action. The western littoral zone of Lake Okeechobee is designated as critical habitat. Similar effects on the species status can be observed in other portions of the snail kite critical habitat including the WCAs. Although there may be similar effects to critical habitat outside Lake Okeechobee, these can largely be attributed to other Federal and non-Federal actions.

EFFECTS OF THE ACTION

This section summarizes the effects of the action on the snail kite habitat within the littoral zone of Lake Okeechobee. Because the majority of the suitable snail kite habitat within Lake Okeechobee is designated as critical habitat, all discussion within this document related to the effects to snail kite habitat within the lake also apply to the critical habitat within Lake Okeechobee.

Any alternative that does not substantially “flatten” the annual hydrograph can be only marginally successful at restoring the lake’s littoral zone close to the more favorable vegetation patterns in the Pesnell and Brown (1977) littoral zone survey, but should improve it compared to current conditions. However, this cannot be achieved with the current infrastructure surrounding the lake; storage that is much more dynamic will need to be connected to the lake. Lowering the annual average lake elevation typically results in lowering the probability of ecological stress due to high lake stages, yet increasing the probability of stress because of low lake stages. Of particular concern is the suitability of the littoral habitat for the apple snail, which is a nearly exclusive food source for the endangered snail kite.

Long-term lake stages above 15.0 ft are destructive to snail habitat. Once the water depth in a particular area exceeds about 16 inches, the area is too deep to allow snails to breed. Deeper water also allows wind storms to tear out emergent vegetation, particularly along the outer edge of the littoral zone. Because the snails must breathe air, they need stems to climb to survive; they also need portions of the stems to remain above water level for their eggs to hatch. When the extremely high lake stages are regularly interspersed with extremely low lake stages, apple snails have no opportunity to recover their numbers. High stages will indirectly affect kites by reducing the abundance, growth, and reproduction of apple snails. High water levels result in reduced growth rates of young snails and fewer adult-size snails are available for snail kites. If the apple snail population becomes depressed, it may require several years of favorable environmental conditions to recover.

The proposed action (Alternative E) would decrease the amount of time that the lake experiences environmentally damaging, extreme high lake stages. Several performance measures were used to evaluate simulations of proposed alternatives. The number of times throughout the period of record that the lake stage would exceed 15 ft for periods longer than 365 days was reduced from two events in the No Action alternative to zero events in the TSP. Prolonged stages above 15 ft were thought to be responsible for the loss of the bulrush fringe of the littoral zone in the 1994-

1995 period. Additionally, the number of times that the lake stage would exceed 17 ft was reduced from 11 events in the No Action alternative to 2 events in the TSP (see Table 5). High lake stages drown emergent vegetation and apple snails and have other adverse effects, including the uprooting of large areas of emergent vegetation by wave action (Havens et al. 2001). In addition to the adverse effects on the emergent plants forming snail kite habitat, extended periods of high water adversely affect submerged aquatic vegetation (Havens and Gawlik 2005) and the largemouth bass fishery (Havens et al. 2005). The Service notes that the extended periods of high water in 1994-1995 had long-lasting effects on habitat structure in the littoral zone of the lake. We believe that the reduction in peak lake stages would be beneficial overall to the snail kite.

Table 5. High lake stage comparison between the 2007LORS No Action alternative and Alternative E as a function of percentage of the 36 year period of record (POR).

2007LORS	Lake Stage							
	15.0 ft	15.5 ft	16.0 ft	16.5 ft	17.0 ft	17.5 ft	18.0 ft	18.5 ft
# events	21	24	20	15	11	9	2	1
avg duration (days)	193	126	97	61	48	22	16	2
% POR	30.8%	23.0%	14.7%	7.0%	4.0%	1.5%	0.2%	<0.1%

ALT-E	Lake Stage							
	15.0 ft	15.5 ft	16.0 ft	16.5 ft	17.0 ft	17.5 ft	18.0 ft	18.5 ft
# events	34	18	14	10	2	0	0	0
avg duration (days)	67	67	44	19	14	0	0	0
% POR	17.4%	9.1%	4.7%	1.4%	0.2%	0.0%	0.0%	0.0%

The model simulations indicate that Alternative E would decrease the area of submerged habitat available for apple snails and snail kites by increasing the frequency and duration of drying events in some years. It will also, however, decrease the number of high water events that adversely affect snails. Table 6 shows a comparison between the proposed alternative and the No Action alternative with respect to the periods in which the lake stage falls below specific elevations, in half-foot intervals.

Table 6. Low lake stage comparison between the 2007LORS No Action alternative and Alternative E as a function of percentage of the 36 year period of record (POR).

2007LORS	Lake Stage								
	9.5 ft	10.0 ft	10.5 ft	11.0 ft	11.5 ft	12.0 ft	12.5 ft	13.0 ft	13.5 ft
# events	1	3	7	11	14	18	23	23	23
avg duration (days)	4	42	38	62	84	99	117	159	219
% POR	0.0%	1.0%	2.0%	5.2%	8.9%	13.6%	20.5%	27.8%	38.3%

ALT-E	Lake Stage								
	9.5 ft	10.0 ft	10.5 ft	11.0 ft	11.5 ft	12.0 ft	12.5 ft	13.0 ft	13.5 ft
# events	5	10	16	23	25	21	27	27	31
avg duration (days)	53	61	67	72	110	175	184	227	236
% POR	2.0%	4.6%	8.1%	12.6%	20.9%	27.9%	37.9%	46.6%	55.5%

The basis of our determination that the proposed action may adversely affect the snail kite is the increased probability that the littoral zone will dry more frequently and for longer duration, relative to the No Action alternative. Our concern for the effects to snail kites closely coincides with the established Minimum Flows and Levels (MFL) for Lake Okeechobee (section 373.042(1), *Florida Statute*). The MFL documentation for Lake Okeechobee states that the harmful lake stage of <11 ft for >80 days should not occur more than once every six years. However, the Service believes that these extreme low lake levels should occur even less frequently, because our current understanding of apple snail recovery suggests a lag time of up to five years after extreme drought to reach optimal densities. We believe that the proper return frequency for a stage of <11 ft for >80 days to sustain snail kite habitat may be on the order of every 8 to 10 years. The final TSP (Alternative E) slightly increases the number of times the lake drops below 11 ft for more than 80 days compared to the 2007LORS base condition (an increase from five to six times). The lake stage hydrograph for the period of record indicates that the low lake stages from the TSP tend to be grouped into three periods when two low water events occur within 6 years of each other, resulting in three violations of the MFL regulations. In contrast, the 2007LORS base run shows two violations of the MFL.

The Service has consulted with Dr. Wolf Mooij of the Netherlands Institute of Ecology regarding use of the “Everkite” model that he developed with assistance from the USGS and the Service. “Everkite” is a spatially-explicit individual-based simulation model that aims at predicting the population dynamics of the Everglade snail kite under various hydrological regimes in Florida’s major wetlands. We believe that “Everkite” does not adequately take into account the short-term and long-term adverse impacts of extreme high water stress in snail kite habitat. We discussed this issue when Dr. Mooij visited our office on February 6, 2007. We will continue to work with Dr. Mooij to improve the “Everkite” model to weigh appropriately the impacts to snail kites of both high and low water extremes in the simulation.

The Service has reviewed the available information on the use and application of population viability analyses (PVA) as a species management tool. Reed et al. (2002) reviewed the status and trends in use of PVAs; they state that PVAs, “... have become a commonly used tool in endangered species management.” They caution against the use of complex commercially available PVA software if individuals do not have modeling expertise, because “... there is a greater potential for misuse of models and increased confusion over interpreting their results.” They provide several recommendations on appropriate uses of PVAs, and advocate not using PVAs to determine minimum population size or the specific probability of reaching extinction. Ralls et al. (2002) suggest that rather than attempting to define an *absolute* risk of extinction, assessing *relative* risk of extinction is one of the better uses of PVAs. For example, they believe PVAs can be of use in answering a question such as, “Which of these management plans would be most beneficial to this species?” They also discuss the use of PVAs in cases where *absolute*

risk of extinction should be estimated, such as assessing risks under the regulatory requirements of the Act. In such cases, however, they recommend that the uncertainty that arises from both model structure and model parameters be quantified; and they recommend adding “safety factors” into the simulation to help compensate for our uncertainty about modeling results.

Beissinger (1995) was the first to perform a PVA for the snail kite. He analyzed the effects of drought years using stage-based life tables for three different water conditions or environmental states (drought, lag years following drought, and high years). Beissinger stated that, “. . . populations became viable when initial size surpassed 300 individuals.” However, his analysis was based on the older mid-winter snail kite census data. He stated that, “Although these counts are fraught with problems of inaccuracy (Rodgers et al. 1988), they are nevertheless useful indicators of the relative magnitude of kite population changes from year to year.” Beissinger (1995) included deterministic simulations to explore the effect of drought frequency on population viability. His simulations suggested that, assuming an initial population size of 300 birds, the snail kite population would decline if droughts occurred more frequently than once every 3.33 years (3 years in a decade). He recommended improvements to this first PVA; including the need for a better estimate of adult survival (his model was very sensitive to changes in this parameter), and the possibility of introducing a spatial component to the model. Since Beissinger’s (1995) work in the period from 1997 to 2006, a more reliable population estimate, based on a mark-recapture technique, has shown a minimum of 1,162 and a maximum of 3,577 individuals (Figure 7 of this Biological Opinion). Had the more recent information on snail kite demography, including a better estimate of total population, been available to Beissinger in 1995, we are uncertain whether he would have retained similar conclusions and recommendations.

Between November 2006 and March 2007, the Service provided comments on a preliminary draft of a more recent PVA for the snail kite. This PVA was first mentioned in the 2003 Snail Kite Demography Annual Report (Martin, Kitchens and Speirs 2003), where it was stated that a preliminary PVA analysis indicated “. . . that under drought patterns close to the historical patterns would now likely lead to a rapid extinction of the Snail Kite in Florida [sic].” Because the PVA used for this analysis was preliminary and never peer-reviewed, conclusions that were drawn from its use were speculative and not reliably interpreted. It should be noted that the intent of the report was to document the results of the annual snail kite survey and its associated data, and was not intended to present, describe or discuss the PVA. Based on concerns about the viability of the kites, the Service in 2005 provided funding to the researchers to further develop and refine the PVA. We have reviewed an updated, but still draft, version of the PVA in August 2007 (Martin, Kitchens, Oli et al. 2007; Martin, Kitchens, Cattau et al. 2007). These manuscripts analyze the years before and after 1998, testing three hypotheses relative to a decline in population growth rate in those two periods. The researchers believe that a combination of both a shift in vegetation communities and an increase in the frequency of moderate drying events contributed to the observed decline in kites. The PVA simulations suggest a probability greater than 0.70 of quasi-extinction within the next 50 years, if conditions similar to the period of 1997 to 2004 are repeated. Quasi-extinction risk is the probability of a population falling below a critical density – an extremely undesirable population level that may be unlikely to be recoverable even with drastic management steps, such as captive breeding. The researchers

chose a threshold of quasi-extinction of 50 females. We note that the Martin, Kitchens, Oli et al. (2007) manuscript cautions against interpreting the quasi-extinction probabilities literally, and they also state that population projection models are “... particularly useful for evaluating the importance of demographic or environmental factors in influencing population dynamics.” This idea supports their use of the model as a sensitivity analysis and an exploratory analysis.

Some of our preliminary findings from the Martin, Kitchens, Oli et al. (2007) manuscript are the following:

- detection probability of birds affects the probability of quasi-extinction;
- the model does not have an explicit spatial component – therefore it does not specifically address the habitat in Lake Okeechobee;
- the exploratory analyses encompassed six objectives, three hypotheses, and ten environmental conditions, under three different detection probabilities;
- the probability of quasi-extinction is based on simulations that use the frequency of wet, moderately dry, and drought years in the period from 1997 to 2004;
- the conditions modeled are based on observations of WCA-3A, and these may not be representative of all areas in the range of the species;
- adult fertility and adult survival seem to be the most sensitive model parameters;
- changes in fertility contribute most to the differences in the modeled population, when comparing pre-1998 to post-1998; and
- if simulations include both a hypothesis of habitat degradation and a hypothesis of increasing the frequency of moderate drying events, these two factors combined have a greater effect in reducing population growth in the model than what may actually occur, thereby overestimating risk.

We regard PVAs as one of many evaluation tools to assess the risks to a species. We have carefully considered this and all other information in reaching a conclusion about the action proposed here. Shaffer et al. (2002) provided a review of the use of PVAs in conservation policy. They suggest that despite their limitations, PVAs are useful, particularly in that they provide a framework for organizing what is known and what is not known about the population and the habitat dynamics of species at risk. They cite the lack of suitable data as historically one of the main limitations of PVAs. While biologists are never fully satisfied that we know

everything we need to know about any species, we believe that relative to other endangered species, scientists have studied the snail kite for several decades, and we have quite good data on their movements and demographics, including some confidence in the estimate of total population. We believe that the greatest uncertainty in estimating an absolute risk of extinction lies in the model assumptions about what Shaffer et al. (2002) call, “ . . . the relative hierarchy and functional form of the relationship between three categories of chance events (demographic, environmental, and catastrophic).” The snail kite has evolved in a highly variable environment and, consequently, has some resilience to the extremes of flood and drought. We know that water management decisions can exacerbate these extremes. The Service has carefully considered the value and limitations of the available draft PVAs along with all other scientific data and tools to develop our analysis of effects to the snail kite.

The Service believes that although the slightly increased risk of extended periods of low water is an adverse aspect of the proposed regulation schedule (particularly for apple snails and snail kites), we believe the change is relatively small. We have also described above at least three ways in which the snail kite has some degree of resilience to this change. First, our recently completed analysis of the lake bottom elevation around nest sites indicates that snail kites nested in locations about one foot lower in the 1987-1991 period than in the 2000-2006 period. This suggests an ability for apple snails and snail kites to shift their distribution again to lower elevations in response to lower average lake stage. Second, our analysis of the moderately severe drought of 1990 indicates that snail kites could continue to nest (albeit at lower numbers) through such a drought and that it is possible following such conditions for snail kites to recover nesting success in the immediately following years. Finally, in more severe droughts, such as 2001 and 2007, snail kites are unable to nest at all in Lake Okeechobee.

The snail kite population can only then be resilient by shifting nesting activity to other portions of its range. In 2007, we believe that although overall reproductive success will diminish, increased nesting activity in the Kissimmee Chain of Lakes can only partially compensate for the absence of nesting habitat in Lake Okeechobee. There are obvious limitations to the extent to which the population can withstand severe stress due to extreme drought. We await data on how severe the impact of the 2007 drought will be in terms of total population estimates, and the return of successful nesting to Lake Okeechobee in subsequent years. We will then reassess the overall risks of increased likelihood of low water levels under these current and future revisions to the water regulation schedule.

It is also difficult to separate what degree of adverse impact on the species could have been avoided by management actions more favorable to the snail kite, and what portion was attributable to extremes in flood and drought beyond the ability of humans to control. We must consider that the snail kite is a relatively long-lived bird, and that even prior to human management of Lake Okeechobee and the Everglades, the population experienced fluctuations in response to cycles of flood and drought. While both high water and low water extremes can have long-lasting adverse consequences, the Service believes that the reduction in the risk of high water stress in adopting the new schedule balances the increased risk of extended periods of low water conditions.

Critical Habitat (Effects of the Action)

Had Critical Habitat been designated for the snail kite in recent years, regulations would have required publication of a Federal Register Notice that, in addition to describing the geographic extent of the critical habitat, would need to provide information on the “primary constituent elements” (biological and physical attributes that are essential to the species’ conservation, such as: space; food, water and nutrition; cover or shelter; reproduction; and special habitats) that were the reason for the decision to designate or propose the habitat as critical. However, the geographic extent of critical habitat for the snail kite was published in the Federal Register on September 22, 1977, predating the requirement for identification of primary constituent elements. In such cases, the analysis should use the best available scientific and commercial data available to determine and document those characteristics of the designated critical habitat that support the species’ conservation.

The Service has described in other sections of this Biological Opinion the best available scientific information on factors affecting the species. We have considered the physical and biological features essential to the conservation of snail kites within their critical habitat, with emphasis on that portion of the critical habitat within Lake Okeechobee. Suitable water depths and hydroperiods are needed to support a moderately dense wet prairie or marsh community, with a predominance of spikerush, beakrush, and other herbaceous plants. Wet prairies (with interspersed aquatic sloughs) dominated by *Eleocharis* spp. and *Panicum* sp. are necessary for snail kite foraging, while areas with woody shrubs, such as tree islands, are optimal nesting locations (Kitchens et al. 2002). In Lake Okeechobee, the most suitable nesting locations are in shrubs such as willows, with less suitable, but usable, herbaceous nesting substrate in cattails or bulrush. These shrubby patches should be limited in extent and located close to herbaceous-dominated foraging areas of sufficient area to support the rearing of fledglings. Water depths and the timing and rate of water recessions in the normally dry spring season must support survival and reproduction of apple snails during most years. Overly dense stands of vegetation, including rooted stands of cattails and floating tussocks of either cattails or other vegetation, are not suitable for the visual foraging technique of the snail kite even if apple snails are abundant in such areas.

Bennetts, Kitchens et al. (1998) cautioned management agencies that “. . . artificial attempts to create stable habitat by reducing hydrologic variability will be harmful in the long run.” That publication cited as evidence the loss of shrubs that are needed as snail kite nesting substrate, attributable to prolonged deep water in southern WCA 3A. While we agree that this is a valid example, we would also cite the buildup of organic sediments and overly dense growth of emergent vegetation in the Kissimmee Chain of Lakes (important but not officially designated critical habitat), which has been detrimental to foraging habitat for snail kites, and which is partially attributable to overly stable water levels. In contrast to the Kissimmee Chain of Lakes, however, scientific evidence (Havens and Gawlik 2005) supports the hypothesis that Lake Okeechobee exhibits excessive fluctuation in water levels. In both cases, we believe that a recommended average interval between drying events needs stronger scientific evidence. Bennetts, Kitchens et al. (1998) describe Figure 2 in their publication as a “conceptual model” of how habitat suitability for the snail kite may respond to successive years of inundation; however,

Dr. Bennetts has told the Service that the time scale in this figure is somewhat hypothetical. In the opinion of the Service, the scientific evidence is not yet conclusive regarding the ideal interval between drying events to best promote habitat suitability for apple snails and snail kites. Our opinion at this time is that snail kite habitat should dry below ground level no more frequently than about once every 8 to 10 years. Additional management measures beyond merely drying, including scraping and removal of accumulated organic sediments, prescribed fire, or herbicide treatments, all of which have been used in various combinations in Lake Okeechobee and elsewhere in designated critical habitat, have also been applied during low water periods or following intentional drawdowns. Application of such management measures in addition to drying of the habitat might influence decisions about the ideal time interval between drying events, but we want to evaluate more instances of all combinations of lake management techniques before reaching a conclusion. The Service generally supports use of these management tools, but the appropriate frequencies of their use, and how they should be staggered throughout critical habitat to the greatest benefit of the snail kite, are imprecisely known at this time. The Service believes that in addition to long-term assessment of vegetation change in snail kite critical habitat, a key uncertainty is the rate of recovery of apple snail populations to a maximum density following severe drying of Lake Okeechobee, such as following the 2001 and 2007 droughts.

Havens and Gawlik (2005) describe in their conceptual ecological model the stressors that act on overall habitat conditions within the lake, with specific references to stresses on snail kites. This conceptual model discusses the effects of high and low water stressors on the ecology of the lake, which includes the critical habitat within Lake Okeechobee (which is about 10 percent of the snail kite's total critical habitat). Our analysis of the proposed action indicates that it will slightly benefit hydrologic conditions in terms of high water stress, but will also slightly increase the likelihood of low water stress in that portion of the critical habitat within Lake Okeechobee. On balance, we find that the net effect will not result in significant adverse effects on the physical and biological features of the snail kite's critical habitat.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, Tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. This section does not consider future Federal actions that are unrelated to the proposed action because they will require a separate consultation pursuant to section 7 of the Act.

A variety of State and local government actions can directly or indirectly affect water volumes and water quality that could, in turn affect the quantity and quality of habitat for the Everglade snail kite. Municipal and county governments in Florida are required to use a "Comprehensive Plan" or "Growth Management Plan" to guide land use changes under rules promulgated by the Florida Department of Community Affairs (Chapter 163.3164, Florida Statutes). The Florida Department of Community Affairs also requires an Application for Development Approval for larger scale development projects deemed to have a regional impact (Developments of Regional Impact). The Application for Development Approval is not intended to supplant local, state, or Federal permitting procedures, but it provides a comprehensive look at a proposed development.

It also serves as the basic data source for the preparation of the regional planning council's report and recommendations to the local government on the regional impact of the proposed development. Florida's Water Management Districts also govern the permitting of water use for individual development projects, conduct regional water supply studies, and regulate surface water management under their Environmental Resource Permits. To the extent practicable, the Service attempts to track such State and local actions that may affect snail kites or their habitat and provide technical assistance, as appropriate.

While the above actions are not necessarily subject to the consultation requirements of the Act, the Service often becomes aware of such proposals through a variety of public forums, news reports, or through early inquiries by environmental consultants who request a list of threatened or endangered species that may be present in the project area. In the case of a wetland-dependent species such as the snail kite, any early comments by the Service will normally lead to the opportunity for consultations through the Corps' Section 404 permit process.

Actions that are reasonably certain to occur at this time include several Developments of Regional Impact currently under review by the State, particularly in the area surrounding the cities of Kissimmee and St. Cloud. These developments are located around or adjacent to the Kissimmee Chain of Lakes, an important habitat region in the northern portion of the snail kite's range. In addition to more local impacts on water quantity, quality, timing, and distribution in the Kissimmee Chain of Lakes, project designs are expected to address the potential impact of such developments on downstream habitat for the snail kite, including the Kissimmee River, Lake Okeechobee and the Everglades. Another area of reasonably certain additional development that is adjacent to important snail kite habitat is in Palm Beach County, around Grassy Waters Preserve. Grassy Waters Preserve is managed by the City of West Palm Beach as part of its water supply. Although water management decisions by the city are not directly subject to Federal oversight under the Act, the Service is an active planning partner in the North Palm Beach County Project (a component of the CERP), and this project is addressing future water management in this area, subject to consultation with the Corps' Planning Division. We are confident that any additional development proposals surrounding Grassy Waters preserve will be addressed by the Service through consultation with the Corps' regulatory program.

We have discussed above in the "Effects of the Action" section of this Biological Opinion the District's established MFL for Lake Okeechobee. In response to the increased likelihood of violating the MFL under the TSP during drought conditions, we are reasonably certain that the Service will continue discussions with the District on appropriate measures for an MFL recovery plan as specified in State law.

One of the principal ways the Service keeps informed on local, State, and private actions that may affect habitat conditions (including snail kite habitat) in Lake Okeechobee is through our membership in the Lake Okeechobee Committee of the Water Resources Advisory Commission, which is advisory to the Governing Board of the District. Through this monthly public forum, we recently became aware of the Statewide Fertilizer Rule, proposed revisions to the District's Environmental Resources Permit Rule, and issues related to backpumping water into Lake Okeechobee. The Service has an opportunity to comment on potential effects on the snail kite

even if there is no Federal consultation nexus, and if a later consultation is required with a Federal action agency on some of these actions, this forum provides the opportunity to initiate early informal consultation.

In summary, although cumulative effects on snail kites and snail kite critical habitat may occur, they would likely be limited in scope, because the larger developments which may affect wetlands or water quality and quantity are anticipated to require a Corps permit. Consequently, these actions are subject to section 7 consultation under the Act.

CONCLUSION

Snail Kite

The proposed revision to the schedule will likely perform better for the health of the lake during years with above average rainfall, but also will entail an increased risk of drying out the entire littoral zone more frequently during drought years. The Service agrees that periodically drying the littoral zone of Lake Okeechobee is ecologically beneficial. However, our analysis suggests that the lowering of the lake without additional storage around the lake runs the risk of drying the lake more frequently than is beneficial to the snail kite and other fish and wildlife. These species rely on inundation of the littoral zone with shallow surface water during most years. The increase in the number of times the Lake is below 11 feet MSL for 80 consecutive days is from five to six times. We are unable to ignore this increased risk, but we also have to give weight to the extensive and long-lasting damage to the littoral zone observed following the extended high water conditions in the 1994-1995 El Niño event. While both high water and low water extremes can have long-lasting adverse consequences, the Service believes that the reduction in the risk of high water stress in adopting the new schedule balances the increased risk of extended periods of low water conditions. The Service believes that although the slightly increased risk of extended periods of low water is an adverse aspect of the proposed regulation schedule, we believe the change is relatively small. We have also described above at least three ways in which the snail kite has some degree of resilience to this change.

We must also keep in mind that the presently proposed schedule is expected to be in place for about 3 years. We are aware that the detailed comparisons of model simulations are based on the precipitation patterns in the years 1965 to 2000. This allows the study team to look at the response of the alternatives to a range of climate cycles. We must recognize that this is in no way a prediction of climate conditions over the next 3 years. Model output analysis can only identify tendencies and probabilities, ranging from the probability of flooding in high rainfall years to the probability of water shortages in drought years. Lowering the average water stage in the lake with the presently proposed schedule will be judged a wise decision if the next 3 years predominantly include periods of high precipitation. Our concerns in this formal consultation are predicated on the increased risks to the ecology of the lake's littoral zone if the next 3 years include a period of drought. The next phase of formulating and selecting a lake regulation schedule (2007 to 2010) will incorporate the Band 1 projects of the Comprehensive Everglades Restoration Plan.

Snail Kite Critical Habitat

Although there are no primary constituent elements designated for the snail kite's critical habitat, we find that the critical habitat will remain functional within Lake Okeechobee and that this action will not significantly affect the other portions of the critical habitat. We have described above the basis for our finding that the proposed change to the regulation schedule has both positive (reduction in high water stress) and negative (increased risk of drying the littoral zone) aspects. Both high water and low water extremes affect the suitability of habitat for foraging and nesting of snail kites in that portion of the species' critical habitat in Lake Okeechobee. Our analysis indicates that, as a net result, the physical and biological factors necessary for this portion of the snail kite's critical habitat to support conservation of snail kites would remain functional. After reviewing the status of the Everglade snail kite, the environmental baseline for the action area, and the effects of the proposed action, it is the Service's biological opinion that this revision to the Lake Okeechobee regulation schedule is not likely to jeopardize the continued existence of the Everglade snail kite, and is not likely to destroy or adversely modify its designated critical habitat.

INCIDENTAL TAKE STATEMENT

Sections 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns, which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary, and must be undertaken by the Corps so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in action 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the Corps must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement.

AMOUNT OR EXTENT OF TAKE

The Service anticipates that incidental take of Everglade snail kites will be difficult to detect for the following reasons: the snail kite is relatively secretive and occupies expansive areas of marshes where it is unlikely that injury or mortality of individuals will be detected and where it is unlikely that all snail kites will be detected by monitoring crews. However, take of this species, in the form injury or death of kites, including eggs and nestlings, is possible.

Estimation of the level of habitat conversion that may have occurred in past years and comparing it to what may be expected in the future is also difficult. The water management infrastructure for Lake Okeechobee and south Florida has changed over several decades and the climatic conditions likely have changed as well.

As we have described in the Baseline section of this opinion, the vegetation patterns in the littoral zone in 1973 described by Pesnell and Brown (1977) were favorable in supporting foraging and nesting by snail kites. We believe that the adverse changes in vegetation since that time are largely due to management actions in the broader ecosystem, and we have therefore chosen to analyze the extent of future changes in foraging habitat as an indicator of incidental take for snail kites. Not only is the abundance of apple snails important, but also the availability of the snails to foraging snail kites, which is largely determined by the density of the vegetation. Therefore, the change in the quality of kite foraging habitat is the primary method used to estimate incidental take.

Our analysis of the potential adverse impacts on snail kite habitat was predicated on the reduction of optimal apple snail habitat and the availability of apple snails to snail kites as a food source. While this habitat change is related to the use of Lake Okeechobee as snail kite habitat, it cannot be used to predict a specific change in the total population of snail kites. We expect that the implementation of the new regulation schedule will begin the process of improving these habitat conditions. Although we may be unable to achieve with this new regulation schedule the level of optimal habitat as was present in 1973, we believe that the quantity of optimal habitat should not continue to decline from the amount documented in 2003. We do not anticipate that the proposed action will result in incidental take, as measured through monitoring of changes in vegetation patterns in the littoral zone. The Terms and Conditions described below require the monitoring of changes in distribution and extent of snail kite foraging habitat beginning in 2010. Excluding the situation when marginal habitat may convert into optimal habitat conditions, if the amount of optimal or marginal habitat in 2010 is lower than observed in 2003 (1,912 acres and 32,023 acres respectively), consultation must be reinitiated. Only changes that can be attributed to water management actions will be considered relevant.

The Service will not refer the incidental take of any migratory bird or bald eagle for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703-712), or the Bald Eagle Protection Act of 1940, as amended (16 U.S.C. §§ 668-668d), if such take is in compliance with the terms and conditions (including amount and/or number) specified herein.

EFFECT OF THE TAKE

In the accompanying biological opinion, the Service determined that the level of anticipated take is not likely to result in jeopardy to the species, or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

Because the scope of this study to modify the Lake Okeechobee regulation schedule was limited to current infrastructure, it was unable to resolve the many environmental problems within and surrounding the lake. The Service was directly involved for more than a year in the team that devised and evaluated a series of alternatives. The initial alternatives were quite broad in their approaches to changing the regulation schedule, but based on evaluation of performance measures in simulations, the team turned to an iterative process of refining the most acceptable balance of performance. We believe that the team thoroughly explored all available non-structural means in attempting to reach a balanced result. Because no single schedule is able to handle climatic extremes, the approach was one of "do no significant additional harm" to any of the evaluation areas, while attempting to balance the adverse impacts of extreme climatic events under the continuing concept of "shared adversity," which has been recognized for decades in developing regulation schedules for Lake Okeechobee. Please refer to our draft Fish and Wildlife Coordination Act Report (Service 2007) for our discussion of the balance of environmental effects expected from the Alternative E schedule and for our recommendations to improve evaluation of alternatives in the next phase of development of a regulation schedule in the 2007 to 2010 period.

We assume that the commitment to provide above-ground and below-ground storage as part of CERP remains strong among all involved parties. In the context of this biological opinion, we believe it is inappropriate to include measures involving increased storage, because this was not part of the scope of the study, and because we assume it remains part of the comprehensive multi-agency effort. Operation of the first projects providing additional storage in the C&SF system will be part of the next phase of investigation; these will include the Band 1 features of CERP, including the Everglades Agricultural Area Storage Reservoir (Phase 1), the C-43 Reservoir, and the C-44 Reservoir. Additional phosphorus removal capacity through Stormwater Treatment Areas now under construction should also be available to explore as opportunities to improve management of the entire C&SF system, with Lake Okeechobee at its center. Therefore, we have not included reasonable and prudent measures dealing with structural features that are currently in planning or testing.

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of Everglade snail kites.

1. A crucial life history parameter that needs better direct and empirical correlation with snail kite foraging and nesting success in Lake Okeechobee is the distribution and density of apple snails in the lake. This is not presented as a basic research proposal, rather an essential tool in determining incidental take of snail kites in the lake and evaluating the impact of

management actions in reducing the level of incidental take that occurs across fluctuations in rainfall that occur on the scale of a decade or several decades. The Service has recommended continuous monitoring of apple snails in the lake in Planning Aid Letters and Fish and Wildlife Coordination Act Reports for at least 20 years. In addition to better establishing this relationship, we must know more definitively about the time required for apple snails to become re-established at peak densities in the littoral zone after disturbances, particularly droughts severe enough to dry the entire littoral zone. Additionally, information on apple snail density should provide empirical evidence on what degree of impacts on the snail kite may be expected in less severe or less prolonged low water levels. This would give us a better sense of the balance of ecological benefits and risks in moderate drying of the littoral zone.

2. Our analysis of the history of the snail kite's habitat use of the lake's littoral zone indicates that the presence of a bulrush fringe along the waterward edge of the western littoral zone is essential to sustain snail kite foraging and nesting activity through periods of moderately severe drought. Given that the proposed regulation schedule increases the risk of frequency and severity of drying the littoral zone, we find that existing programs to plant bulrush in that area (in years having appropriate water levels for planting) need to be bolstered.
3. The Corps of Engineers has a role, among several management agencies, in spraying herbicides to control both invasive exotic plant species, and some native species that are considered a nuisance. Multiple agencies have cooperated in minimizing direct disturbance of snail kite nests by following recommendations developed by the Service. We ask the Corps to assist us further in ensuring that these efforts to reduce direct and indirect impacts on the snail kite are as effective as possible. The intent of this effort is to detect and avoid impacts on active snail kite nests, through general education of spray crews about the sensitivity of snail kites and the frequent dissemination of information on the location of active nests throughout each nesting season.
4. Measurement of the quantity and location of optimal and marginal habitat based on mapping of vegetation communities is the basis for determining the level of incidental take that is occurring in Lake Okeechobee. This will require that vegetation surveys be performed on a regular basis in a way that allows comparison to the most recent survey in 2003. We ask that the next survey be performed in 2010 in order to measure incidental take resulting from this action. Should this project extend longer than the expected three years, additional surveys should be conducted at five-year intervals until the next consultation is conducted for the lake's regulation schedule. The vegetation surveys should be designed to specifically identify plant communities that are most suitable to providing habitat for snail kites, and the Service encourages the applicant to coordinate with snail kite experts when developing the survey methods to ensure that the vegetation mapping scheme is appropriate.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the reasonable and prudent measures,

described above and outline required reporting/monitoring requirements. These terms and conditions are nondiscretionary.

1. The Corps will implement an apple snail monitoring program within the littoral zone of Lake Okeechobee. In order to encompass a range of climate conditions, this program should be conducted annually for the duration of this regulation schedule. The scope of monitoring should allow an analysis across the bathymetric gradient of the western littoral zone, from Herbert Hoover Dike to the waterward edge of the littoral zone, and should include general vegetative descriptions of the sample sites. Of particular importance are Moonshine Bay and the outer portion of Observation Shoal that once supported an extensive bulrush community.
2. The Corps will ensure that a vegetation survey is performed in 2010 for Lake Okeechobee, in a way that it can be compared to the baseline vegetation data as a measure of the change in suitable habitat for the snail kite. Additional surveys should be conducted at five-year intervals until the next consultation is conducted for the lake's regulation schedule.

Upon locating a dead, injured, or sick specimen of any threatened or endangered species, initial notification must be made to the nearest Service Law Enforcement Office (Fish and Wildlife Service; 9549 Koger Boulevard, Suite 111; St. Petersburg, Florida 33702; 727-570-5398). Secondary notification should be made to the Florida Fish and Wildlife Conservation Commission; South Region, 3900 Drane Field Road, Lakeland, Florida, 33811-1299; 800-282-8002. Care should be taken in handling sick or injured specimens to ensure effective treatment and care or in the handling of dead specimens to preserve biological material in the best possible state for later analysis as to the cause of death. In conjunction with the care of sick or injured specimens or preservation of biological materials from a dead animal, the finder has the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

The Service believes that no loss of the estimated 1,912 acres of optimal habitat or the 32,023 acres of marginal habitat (2003 data) will occur by 2010 (with the exception of the situation when marginal habitat may convert into optimal habitat conditions). We anticipate that this acreage can be increased relative to the 2003 estimate, based on the 2010 vegetation survey. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Corps must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to further minimize

or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

Other than the continuation of ongoing programs to track the number and fate of snail kite nests throughout the species' range, the Service has two conservation recommendations at this time.

1. When the littoral zone of Lake Okeechobee is not covered by water (at a lake stage of about 11 ft NGVD), we recommend that the Corps use an airborne Light Detection and Ranging (LIDAR) system to better map elevation contours of the lake's littoral zone. This will allow better modeling and assessment of potential effects of lake stages on a variety of fish and wildlife, including apple snails and snail kites.
2. The Corps will continue to cooperate with the Service and other agencies performing aquatic plant management in Lake Okeechobee and other portions of the snail kite range where these activities take place to minimize or avoid disturbance or loss of active snail kite nests. The assistance we are seeking has five elements:
 - a. basic training and orientation of aquatic plant management crews;
 - b. reporting information and observations from crews to the Service;
 - c. dissemination of snail kite nest information from the Service to the crews;
 - d. improved communication among various agencies conducting aquatic plant management about their planned activities; and
 - e. development of new methods to control aquatic plants and to protect snail kites from disturbance from these activities.
3. The concept of "seeding" apple snails into the littoral zone as a measure to recover from extreme drought has been discussed in public forums (e.g., the Lake Okeechobee Subcommittee of the Water Resources Advisory Commission). The Service is open to testing the potential benefits of such a strategy at the scale of a pilot study prior to evaluating its potential use at a larger scale. We recommend the Corps conduct a demonstration that captive breeding of snails and/or transplanting snail egg clusters in the field may significantly accelerate repopulation of apple snails in a large water body such as Lake Okeechobee.

Service requests notification of the implementation of any conservation recommendations and to be informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats.

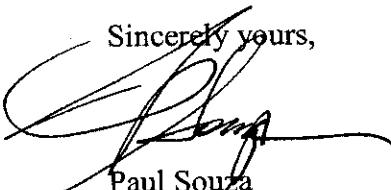
REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the reinitiation request. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

- (1) the amount or extent of incidental take is exceeded;
- (2) new information reveals effects of the Corps' action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion;
- (3) the Corps' action is later modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or
- (4) a new species is listed or critical habitat designated that may be affected by the action.

In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation of consultation.

Thank you for your cooperation and effort in protecting fish and wildlife resources. If you have any questions on this project, please contact me at 772-562-3909.

Sincerely yours,

Paul Souza
Field Supervisor
South Florida Ecological Services Office

cc:

Corps, Planning Division, Jacksonville, Florida (Stuart Appelbaum)
District, West Palm Beach, Florida (Carol Wehle)
FWC, Tallahassee, Florida (Mary Ann Poole)
FWC, Vero Beach, Florida (Timothy Towles)
NPS/ENP, Homestead, Florida (Dan Kimbell)
Service, Atlanta, Georgia (Noreen Walsh) electronic copy only
SOL/DOI, Atlanta, Georgia (Michael Stevens)
Service, Jacksonville, Florida (Myles Meyer)
Service, Vero Beach, Florida (Tylan Dean) electronic copy only

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960



October 12, 2007

Colonel Paul L. Grosskruger
District Commander
U.S. Army Corps of Engineers
701 San Marco Boulevard, Room 372
Jacksonville, Florida 32207-8175

Service Federal Activity Code: 41420-2006-FA-0407
Project: Lake Okeechobee
Regulation Schedule

Dear Colonel Grosskruger:

The enclosed report is the final Fish and Wildlife Coordination Act (FWCA) report on the Lake Okeechobee Regulation Schedule Study (LORSS). This report is based on the Tentatively Selected Plan as described and analyzed in the U.S. Army Corps of Engineers' (Corps') revised draft Supplemental Environmental Impact Statement (SEIS). This report is provided by the U.S. Fish and Wildlife Service (Service) in accordance with the FWCA of 1958, as amended (48 Stat. 401; 16 U.S.C. 661 *et seq.*) and the Endangered Species Act of 1973, as amended (ESA) (87 Stat. 884; 16 U.S.C. 1531 *et seq.*). This report constitutes the Secretary of the Interior's recommendations for the LORSS, in accordance with section 2(b) of the FWCA, and will be incorporated into the Corps' final SEIS for public review and comment in accordance with the provisions of the National Environmental Policy Act.

The Service, Corps, South Florida Water Management District, and other state and local entities have cooperated extensively over the past two years to plan this project. This FWCA report provides the Service's continuing guidance and recommendations for the benefit of fish and wildlife resources related to Lake Okeechobee and the downstream ecosystems affected by water releases from the lake. On August 15, 2007, the Florida Fish and Wildlife Conservation Commission concurred with the findings in our draft FWCA report, and a copy of their letter of concurrence is included as Appendix A in this final report.

This report does not constitute a Biological Opinion as described under section 7 of the ESA. The Service is currently in the process of preparing a Biological Opinion for this project, which will address the project impacts on the Everglade snail kite (*Rostrhamus sociabilis plumbeus*). If you or your staff has any questions regarding the findings and recommendations contained in this report, please contact Bob Pace at 772-562-3909, extension 239, or Doug

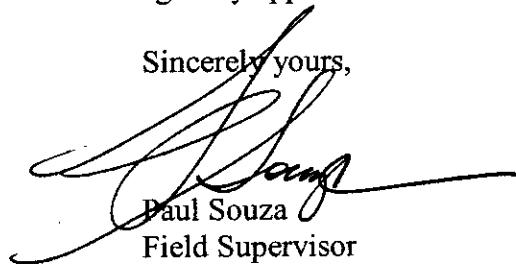


Colonel Paul L. Grosskruger

Page 2

Chaltry at 772-562-3909, extension 320. The cooperation of your staff and the staff of the South Florida Water Management District is greatly appreciated.

Sincerely yours,



A handwritten signature in black ink, appearing to read "Paul Souza".

Paul Souza
Field Supervisor
South Florida Ecological Services Office

Enclosure

cc: w/enclosure

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Final Fish and Wildlife Coordination Act Report

2006 LAKE OKEECHOBEE REGULATION SCHEDULE STUDY



Submitted to:
Jacksonville District
U.S. Army Corps of Engineers
Jacksonville, Florida

Prepared by: Bob Pace, Doug Chaltry, Margaret Wilson
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Fish and Wildlife Service
South Florida Ecological Services Office
Vero Beach, Florida

October 12, 2007

EXECUTIVE SUMMARY

The U.S. Fish and Wildlife Service (Service) has long been aware of the limitations of the current infrastructure surrounding Lake Okeechobee in dealing with extremes in climate and the inherent tradeoffs among competing project purposes. We have participated throughout formulation of alternatives, their evaluation and modification to try to seek a reasonable balance in this “shared adversity.” We support the U.S. Army Corps of Engineers (Corps) efforts in reformulating the tentatively selected plan that was initially presented to the public in the fall of 2006. We recognize the intent to reduce periods of high lake stage to also reduce the probability of a potential structural failure of the Herbert Hoover Dike that surrounds the lake. However, we were concerned that the rigid constraint of having no days in the 36-year simulation with a lake stage above 17.25 feet produced damaging high flow events of greater duration than in the No Action alternative. During reformulation and additional analysis in November and December 2006, the absolute constraint on stages over 17.25 feet was slightly relaxed, with the result that none of the main ecosystems evaluated in the study are likely to suffer additional damage beyond the levels they are currently experiencing.

One of the positive aspects of the revised schedule (beyond the additional security for the Herbert Hoover Dike) is the predicted increase in the total time, during periods of low rainfall, that the Minimum Flows and Levels criterion for the Caloosahatchee estuary can be met. Although this is a benefit, we believe this goal is secondary to reducing damaging high flows to the Caloosahatchee. The selected plan is not anticipated to be appreciably different than the No Action alternative for high flows under normal climate conditions. The selected plan is scheduled to be in effect for approximately 3 years; except for years with heavy tropical storm activity, the Caloosahatchee estuary would likely benefit from the selected plan. The St. Lucie estuary does not have a minimum flow criterion, but the incidence of damaging high flow rates down the St. Lucie Canal would be similar to the No Action alternative.

With respect to effects on the lake’s ecologically valuable littoral habitat, the Service supports the idea that reduction of damaging high lake stages should be weighed more heavily in the evaluation of alternatives than the reduction of the period of stress to the ecosystem due to droughts. The anticipated reduction in the duration of damaging high lake stages is a benefit of the selected plan. However, without additional water storage in the system, we have observed that lowering the peaks of the high lake stages generally cannot be accomplished without a concurrent lowering of the low water levels during drought, which could have adverse effects on the lake’s littoral marshes. Graphically, this is depicted as a lowering of the entire modeled stage hydrograph for the lake, with all its peaks and troughs. In the future, with more dynamic storage in the system, the intent is, on average, to compress both the extreme highs and lows towards a more ecologically favorable “lake stage envelope.” Therefore, the proposed revision to the schedule will likely perform better for the health of the lake during years with above average rainfall, but also will entail an increased risk of drying out the entire littoral zone more frequently during drought years. The Service agrees that periodically drying the littoral zone of Lake Okeechobee is ecologically beneficial. However, our analysis suggests that the lowering of the lake without additional storage around the lake runs the risk of drying the lake more frequently

than is beneficial to a wide range of fish and wildlife that need the majority of the littoral zone to be inundated with shallow surface water during most years.

The Service analyzed the performance measure output for the Water Conservation Areas and Everglades National Park. The modeling of project alternatives suggests that the difference in performance between the proposed alternatives and the No Action alternative is so small as to approach insignificance, often around 1 percent. We believe that this is partly due to the lack of sensitivity of the South Florida Water Management Model (2x2 model) in detecting such small changes, but it is also partly due to practical constraints imposed on all of the evaluated alternatives. Sending water south to the remnant Everglades is strictly limited in the simulations due to the limited capacity to cleanse water through the existing set of treatment marshes.

We are providing a number of recommendations in this report, most of them focusing on ways to improve the analysis during the next phase (2008 to 2010) of formulating and selecting a lake regulation schedule that will incorporate the Band 1 projects of the Comprehensive Everglades Restoration Plan; the presently proposed schedule is expected to be in place for about 3 years. The detailed comparisons of model simulations are currently based on the precipitation patterns in the years 1965 to 2000. This allows the study team to look at the response of the alternatives to a wide range of climatic conditions. However, we cannot predict the climate conditions that will occur over the next 3 years. Model output analysis can only identify trends and probabilities, ranging from the probability of flooding in high rainfall years to the probability of water shortages in drought years. Lowering the average water stages in the lake with the presently proposed schedule will be beneficial to fish and wildlife resources if the next 3 years include periods of high precipitation. Conversely, the attached report also includes a discussion of the increased risks to the ecology of the lake's littoral zone if the next 3 years include a period of drought, such as the lake is currently experiencing.

Despite our inability to accurately predict long-range climate patterns, the study team used the best available analytical tools and agency experts to develop a regulation schedule that balances the competing goals for the lake. We appreciate the willingness of the Corps to reformulate alternatives and gain the consensus of the study team on the selected schedule that provides the best overall performance.

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LIST OF ACRONYMS AND ABBREVIATIONS USED IN THE TEXT

af	acre-feet (325,851 gallons per acre-foot of water)
Alt-T3	Alternative T3
BO	Biological Opinion
C&SF	Central and Southern Florida
CERP	Comprehensive Everglades Restoration Plan
cfs	cubic feet per second
CLA	Class Limit Adjustments (modification to WSE)
Corps	U.S. Army Corps of Engineers
CSOP	Combined Structural and Operational Plan
District	South Florida Water Management District
EA	Environmental Assessment
EAA	Everglades Agricultural Area
EIS	Environmental Impact Statement
ENP	Everglades National Park
ESA	Endangered Species Act of 1973, as amended (87 Stat. 884; 16 U.S.C. 1531 <i>et seq.</i>)
F.S.	Florida Statute
ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
FWCA	Fish and Wildlife Coordination Act
HHD	Herbert Hoover Dike
IOP	Interim Operational Plan
km	kilometers
LEC	Lower East Coast Service Area
LECRWSP	Lower East Coast Regional Water Supply Plan
LONINO	Lake Okeechobee Net Inflow Outlook
LORS	Lake Okeechobee Regulation Schedule
LORSS	Lake Okeechobee Regulation Schedule Study
LOWSM	Lake Okeechobee Water Shortage Management Plan
MFL	Minimum Flows and Levels
NWR	National Wildlife Refuge
PAL	Planning Aid Letter
PDT	Project Delivery Team
ppb	parts per billion
ppt	parts per thousand (salinity)
SAV	Submerged Aquatic Vegetation
SEIS	Supplemental Environmental Impact Statement
Service	Fish and Wildlife Service
SFWMM	South Florida Water Management Model
SSM	Supply Side Management
STA(s)	Stormwater Treatment Area(s)
TSP	Tentatively Selected Plan
WCA(s)	Water Conservation Area(s)
WSE	Water Supply and Environment (the regulation schedule from 2000 to present)

I. PURPOSE, SCOPE, AND AUTHORITY

A. Introduction

The U.S. Army Corps of Engineers (Corps) is preparing a Supplemental Environmental Impact Statement (SEIS) for the Lake Okeechobee Regulation Schedule Study (LORSS). The intent of this SEIS was to evaluate new alternatives for the Lake Okeechobee regulation schedule “in order to optimize environmental benefits at minimal or no impact to the competing project purposes, primarily flood control and water supply” (Corps 2005). However, the study underwent a change during the course of alternative development and evaluation, resulting in an increased emphasis on lowering high lake stages to protect the integrity of the Herbert Hoover Dike (HHD) that surrounds the lake. The project alternatives considered only operational changes to water management structures that discharge water from the lake; no new construction is planned. This schedule will be active for about 3 years (2008-2010), and a new schedule, which will incorporate possible structural improvements along with benefits from initial components of the Comprehensive Everglades Restoration Plan (CERP), will be implemented around 2010.

The proposed water regulation schedule will replace the current schedule referred to as the Water Supply and Environment (WSE) regulation schedule. The tentatively selected plan (TSP), known as Alternative T3 (or Alt-T3) in this study, was identified by the study team to be the alternative that best met the constraints set by the Corps for public safety of the HHD, while at the same time minimizing adverse impacts to water supply, navigation, recreation, fish and wildlife resources in the littoral zone of Lake Okeechobee, and the St. Lucie and Caloosahatchee Estuaries. (Note that the Corps has renamed the TSP in the revised draft SEIS to Alternative E. This FWCA report will continue to refer to the TSP as Alt-T3.)

B. Purpose and Scope of Project

The purpose of the LORSS is to determine if an improved regulation schedule can better accommodate the wide range of extreme weather events that have affected south Florida since the adoption of the WSE regulation schedule 7 years ago. As stated in the Introduction to this section, the original purpose of the study was to develop a regulation schedule that better balanced the multiple, and sometimes competing, objectives for managing water levels in Lake Okeechobee, with emphasis on environmental benefits. The revised project purpose gave greater consideration to lowering lake stage such that acceptable alternatives had to meet the Corps’ intent to further protect the HHD from extreme precipitation events.

To allow expeditious development and implementation of the new regulation schedule, the Corps limited the scope of the project to evaluating only those alternatives that are feasible without changes to the physical infrastructure of canals, levees, pumps, and water control structures around Lake Okeechobee. The geographic scope of the analysis of the alternatives includes Lake Okeechobee, the St. Lucie and Caloosahatchee estuaries, the Water Conservation Areas (WCAs), and Everglades National Park (ENP).

C. Authority

As described in the Notice of Intent for this project (Corps 2005), “Authority for this action is the Flood Control Act of 1948. It authorized the Central and Southern Florida (C&SF) Project, which is a multipurpose project that provides flood control, water supply for municipal, industrial, and agricultural uses; prevention of salt water intrusion; water supply for ENP; and protection of fish and wildlife resources.” The Service provides in this report both short-term and long-term recommendations to conserve and enhance fish and wildlife resources in Lake Okeechobee, consistent with the restoration goals of the CERP.

II. PREVIOUS SERVICE INVOLVEMENT WITH THE LAKE OKEECHOBEE REGULATION SCHEDULE

A. Overview

The Service has a long history of reviewing and providing recommendations to the Corps on the effects of water regulation in Lake Okeechobee. In 1978, the Service issued a Biological Opinion (BO) that implementation of the regulation schedule proposed at that time would not jeopardize the continued existence of the endangered Everglade snail kite (*Rostrhamus sociabilis plumbeus*). That regulation schedule is often referred to as the 1978 Schedule.

The 1978 BO was followed by 20 years of informal endangered species consultations and technical assistance. The Service provided several Planning Aid Letters (PALs) and Fish and Wildlife Coordination Act (FWCA) reports to the Corps addressing various modifications to the regulation schedule, including the extensive plan formulation and in-depth analysis leading to the selection of the WSE schedule in 1999. An informal consultation was conducted on the regulation schedule in 1999, in conjunction with a FWCA report. The Service generally supported the changes to the schedule, either minor modifications, or temporary deviations to the schedule requested by the Corps in response to particular circumstances.

It is important to note that Service policy on the format and content of Incidental Take Statements was not in effect at the time of the 1978 BO; these provisions arose from the Endangered Species Act (ESA) amendments of 1982. The final regulations governing Incidental Take Statements were published in the *Federal Register* on June 3, 1986. The Service is currently preparing a formal consultation for the lake’s proposed regulation schedule.

B. Chronology

The following chronology includes only the major milestones since 1978. Many additional meetings and correspondence are not included in this list.

On March 8, 1978, the Service issued a BO on the Corps’ proposal to raise the LORS from the existing 14.5 - 16.0 feet (ft) schedule to a 15.5 - 17.5 ft schedule (all elevation measurements in this report are expressed in National Geodetic Vertical Datum). The BO was limited to consideration of effects on the endangered snail kite, and concluded that the action was not likely

to jeopardize the continued existence of this species. However, the Service expressed concern that it was difficult to predict the exact response of apple snail (*Pomacea paludosa*) populations to the new regulation schedule, and recommended that the Corps initiate an apple snail monitoring program in the lake's littoral zone, which was designated as critical habitat for the snail kite in 1977.

On June 19, 1978, the Service provided an FWCA report in response to the proposed 1978 schedule. The Service did not oppose implementation of the 1978 schedule, but recommended monitoring of apple snails, the vegetative composition in the littoral zone, the fisheries in the marsh, and rookeries and other breeding areas. The Service also recommended management of water levels within the levees at Torry, Kreamer, and Ritta Islands in the southeastern portion of the lake to create additional marsh habitat.

On September 5, 1985, the Service provided a PAL to the Corps regarding the potential adverse environmental effects of raising the lake's regulation schedule from the 15.5 - 17.5 ft schedule, then in effect, to a 19.5 - 21.5 ft schedule, as part of an effort to increase water supply in south Florida. The PAL cited evidence suggesting that the 1978 schedule, which had at that time been in effect for nearly 6 years, was causing adverse effects on the littoral marsh and its associated fish and wildlife resources. We recommended long-term monitoring of the effects of the 1978 schedule, and recommended against the 19.5 to 21.5 ft schedule, which the Service predicted would eliminate about 55,600 acres of littoral wetlands, including willow-vegetated bars used by wading birds and the snail kite for nesting. The PAL also noted that the Corps had not carried out the Service's 1978 recommendation to partially compensate for adverse effects caused by the 1978 schedule through restoration of marshes at Torry, Kreamer, and Ritta Islands, nor had they yet implemented any apple snail monitoring program.

On June 10, 1987, the Service sent a letter to the South Florida Water Management District (District) requesting re-evaluation of the 1978 schedule, based on the observed stress on the vegetation in the littoral zone.

In 1988, the Lake Okeechobee Littoral Zone Technical Group, a group of wetland and wildlife scientists (including the Service), recommended adoption of a lower lake regulation schedule, known as Run 22, which would operate in zones between 13.5 ft and 15.5 ft.

In 1992, a schedule known as Run 25 was implemented for a 2-year trial period, instead of the recommended Run 22.

On March 18, 1993, the Corps, responding to a request from the District, called for public comments on the Run 22 schedule.

On May 14, 1993, the Service sent a letter to the Corps stating that Run 22, or a similar schedule, would be preferable to the Run 25 schedule for protection of the littoral zone. The letter requested that the Service and the Corps develop a Scope of Work to prepare a draft FWCA report on Run 22. Our files contain copies of a draft Scope of Work, but this was never finalized and the Service never prepared an FWCA report evaluating Run 22.

In May 1994, the Corps held two public hearings on the continued use of Run 25 as the lake's regulation schedule. One of the alternatives considered in that review was Run 22AZE, a modification of Run 22. Following the public hearings, the Corps extended the use of Run 25.

The LORSS began with a June 14, 1995, public notice requesting comment on the alternatives that were under consideration.

The Corps conducted eight week-long sampling efforts in the lake's littoral zone between May 1997 and November 1998. This provided baseline data on vegetation and general observations of fish and wildlife prior to plan formulation for the LORSS. The study did not include sampling for apple snails and included only recorded observations of snail kites in general avifauna surveys. The final report was issued in June 1999, after the Corps had selected a preferred alternative under the LORSS.

On September 24, 1997, the Florida Game and Fresh Water Fish Commission (now the Florida Fish and Wildlife Conservation Commission, or FWC) and the Service jointly sent a PAL to the Corps, which noted that the FWC and the Service preferred Run 22AZE overall among the alternatives under consideration.

On April 15, 1998, the District presented preliminary results of simulations of a newly devised alternative, named WSE. However, the FWC and Service stated to the Governing Board that Run 22AZE remained their preferred alternative.

On September 23, 1998, the Service provided a PAL in response to discussions at a meeting on September 11, 1998, involving development of an implementation strategy for the WSE schedule.

On February 18, 1999, the Corps officially notified the Service that the WSE schedule would be the preferred alternative in the draft EIS for the LORSS. That letter also stated the Corps' determination that the WSE schedule was not likely to adversely affect federally listed threatened or endangered species.

In July 1999, the Service received a copy of the draft EIS for the LORSS. The draft FWCA report had not been completed prior to issuance of the draft EIS.

On July 30, 1999, the Service issued the draft FWCA report on the LORSS. This report concurred with the Corps' determination that implementation of the WSE water regulation schedule was not likely to adversely affect federally listed threatened or endangered species or result in destruction or adverse modification of designated critical habitat. This was based on the data showing that WSE would show slight improvement in damaging high water levels relative to the previous Run 25 schedule.

On October 6, 1999, the Service issued the final FWCA report on the LORSS. The Service recommended that the Corps refine their climate forecasting methodology, conduct studies to

quantify the effects of lake levels on various flora and fauna, and conduct research on lake phosphorus levels. The Service also reiterated the previous recommendations to mitigate adverse effects caused by the 1978 schedule through restoration of marshes at Torry, Kreamer, and Ritta Islands.

After several years of above average rainfall and sustained high water levels, the FWC requested by letter on March 27, 2000, that the Corps investigate a managed recession of lake levels. This was discussed in a public technical meeting at the District on April 11, 2000. The District Governing Board approved the Shared Adversity Plan in April 2000, with the goal of lowering Lake Okeechobee from 14.89 to 13 feet, and holding it at 13 feet for 8 weeks to promote the reestablishment of submerged aquatic vegetation and thereby benefit fish and wildlife. The Service supported this plan. The plan largely accomplished its intended ecological benefits despite two less than desirable characteristics. First, climate predictions proved to be incorrect, and rainfall was not available to hold the lake at 13 ft. Lake stage plummeted to a record low around 9 ft in May 2001. Due to water supply concerns, the District allowed backpumping of water from the Everglades Agricultural Area (EAA) to the lake and temporary forward pumps that allowed delivery of water to the EAA below stages that would be accommodated by the permanent structures on the south side of the lake. The lake stage rose abruptly, but perhaps too fast for maximal ecological benefit following late wet season rains. Nevertheless, the lake stage rose to a desirable level without extended periods of environmentally damaging high stages, and submerged aquatic vegetation (SAV) responded the following spring with greatly increased coverage under excellent water clarity conditions.

The Adaptive Protocols for Lake Okeechobee Operations were accepted by resolution of the Governing Board of the District on January 9, 2003. The Adaptive Protocols provide additional guidance on the consultative process water managers in the District use to decide specific water release volumes within the range of operations allowed under WSE.

On December 8, 2003, the Corps asked the Service to review a temporary deviation from the WSE schedule that would allow Level I Pulse Releases to the St. Lucie and Caloosahatchee estuaries under circumstances not normally considered under WSE. In a December 15, 2003, letter, the Service agreed that the action was likely to provide a net benefit to the system, with benefits mainly in the lake's littoral zone and relatively low risk of harm to the estuaries due to the moderate discharge volumes. The low level releases were also considered beneficial in attempting to reduce the need for higher volume releases later in the wet season.

On May 13, 2004, the Corps issued a letter requesting extension of the temporary deviation until May 31, 2005. The Service concurred with this request on June 2, 2004. The low volume releases would preclude or lessen high volume regulatory discharges to the Caloosahatchee and St. Lucie estuaries.

On September 10, 2004, the Corps provided the Service information regarding the temporary deviation, and a draft Environmental Assessment (EA) that analyzed the Class Limits Adjustment (CLA) alternative, which was a new proposal to adjust the WSE to allow improved water release decisions, mainly on the basis of reclassification of parameters in the decision tree

for WSE related to the Lake Okeechobee Net Inflow Outlook (LONINO) and tributary conditions in the Kissimmee River watershed. The Corps concluded that the CLA alternative would not adversely affect listed species or critical habitat, and they requested our review and comments on the EA.

On November 1, 2004, the Service provided comments on the draft EA for the CLA proposal. Our evaluation concluded that, while the CLA may result in minor negative effects to the estuaries, these effects would be offset by beneficial ecological effects (also minor) within the lake.

In November 2004, the Florida Wildlife Federation sent letters to the Corps and the Service's Regional Director expressing their concern over the current status of the Everglade snail kite and impacts to the kite from water management in Lake Okeechobee. They recommended lowering the average lake elevation to pre-1978 levels and ensuring the continued availability of irrigation water through the use of forward pumps, as had been demonstrated during the 2001 drought.

On December 2, 2004, the Corps sent a letter to the Service that included additional information on their effects determination of the CLA on listed species, and requested our concurrence with their determination of "no effect" on the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), West Indian manatee (*Trichechus manatus*) and eastern indigo snake (*Drymarchon corais couperi*), and a "not likely to adversely affect" determination on the snail kite, bald eagle (*Haliaeetus leucocephalus*), wood stork (*Mycteria americana*) and Okeechobee gourd (*Cucurbita okeechobeensis* ssp. *okeechobeensis*).

The Service responded to the Corps on January 20, 2005. The letter reminded the Corps of previous requests to implement a monitoring study on the apple snail within the littoral zone of the lake, which had not been carried out to date. The letter also informed the Corps that the most current scientific information indicates that the snail kite was faring poorly in Florida, particularly in the littoral zone of Lake Okeechobee, which was historically one of the largest kite breeding areas in the state. The Service recommended that the Corps immediately reinitiate formal consultation on the Lake Okeechobee regulation schedule, and agreed that the CLA should be implemented as an interim conservation measure until conclusion of formal consultation.

On July 21, 2005, the Corps sent a letter to the Service and other stakeholders requesting our input on concerns regarding the WSE regulation schedule, and opinions on how problems with the schedule may be addressed.

On August 3, 2005, the Corps issued a Notice of Intent to prepare a Draft SEIS to evaluate new alternatives for the LORS "in order to optimize environmental benefits at minimal or no impact to the competing project purposes, primarily flood control and water supply."

The Corps sent a species list request to the Service on August 29, 2005, and the Service responded by letter with the species list on September 30, 2005.

The Service sent a letter to the Corps on September 19, 2005, in response to their July 21, 2005, request for initial comments on the lake regulation schedule. A Project Delivery Team (PDT) was established to develop and analyze alternatives to the WSE regulation schedule. The PDT was composed of representatives from the Corps, Service, District, and other local, state and Federal agencies.

On March 8, 2006, the Corps requested informal consultation on a new regulation schedule, with the stated goal to “plan measures to further improve the environmental performance of the [WSE] regulation schedule.”

On May 16, 2006, the Service sent a letter to the Corps recommending selection of Alternative 1aS2 for the new regulation schedule. The Service considered all ecological effects, both within and outside Lake Okeechobee, of the many alternatives that had been modeled. Of particular concern was the effect of lake releases on the downstream estuaries, and in lieu of providing actual restoration of these estuarine systems, we emphasized that the selected plan should at least not cause any additional damage to the estuaries than the “future without project” condition. At that time, the PDT had reached consensus that Alternative 1aS2 was the best “all around” alternative, providing the best balance between slightly lowering the lake stage and limiting large volume discharges to the estuaries as compared to the No Action alternative.

In mid-May 2006, the Corps’ explained to the LORSS PDT that the emphasis regarding project goals had changed in recognition of the perceived threats to the integrity of the HHD. Consequently, those alternatives that did not lower the lake stage to the extent deemed necessary to protect public safety were eliminated from further consideration, including Alternative 1aS2.

On June 30, 2006, the Corps requested initiation of formal consultation on the LORSS, and submitted a Biological Assessment (BA) presenting their analysis of the effects of the recommended plan on several listed species. The alternative that was chosen as the recommended plan was known as Alternative 1bS2-m. The Service acknowledged the receipt of the BA and began formal consultation on July 21, 2006.

On August 10, 2006, the Corps published a Draft SEIS for public review. A draft FWCA report had not been completed in time for inclusion in the Draft SEIS. The Service submitted comments on the Draft SEIS as part of a unified comment letter from the Department of the Interior.

In late October 2006, the Corps project team recommended to Corps management that the PDT should reformulate the project alternatives, craft an improved TSP to address public concerns, and prepare a revised draft of the SEIS to be published for another 30-day public review. Throughout November and December 2006, the PDT developed and analyzed several new variations of the project alternatives, ultimately choosing Alternative T-3 as the TSP.

On November 2, 2006, Service staff met with representatives of Lee County and the City of Sanibel to discuss effects of freshwater discharges from Lake Okeechobee on fish and wildlife resources in the Caloosahatchee estuary.

The release date of the revised draft SEIS was delayed until July 2007 due to unresolved issues related to Minimum Flows and Levels and the District's water shortage management rules. The Service's draft FWCA report was included as an appendix in the revised draft SEIS. Public meetings were held in August 2007.

On August 13, 2007, the Service sent comments to the DOI regarding our evaluation of the revised draft SEIS to be incorporated into the departmental response to the Corps.

On August 15, 2007, the Service received a letter from the FWC concurring with the findings contained within the Service's draft FWCA report.

Following evaluation of the public comments, and a final revision to the SEIS incorporating those comments, a Record of Decision for the new schedule is anticipated to be signed in November 2007.

III. AREA SETTING

A. Project Location

The study area for this project includes Lake Okeechobee, the Caloosahatchee estuary, the St. Lucie estuary, the EAA, and the WCAs south of Lake Okeechobee. Lake Okeechobee is located in south-central Florida, about 100 kilometers (km) south of Orlando and 60 km northwest of Miami, within Okeechobee, Glades, Palm Beach, Martin and Hendry Counties. Figure 1 shows some of the more prominent features of the Lake Okeechobee study area.

B. Description of Study Area

1. Hydrological Description

Lake Okeechobee is the central feature of south Florida's interconnected Kissimmee River/Lake Okeechobee/Everglades watershed. Lake Okeechobee is a shallow subtropical lake that supplies water to the remnant Everglades, Florida Bay, and the St. Lucie and Caloosahatchee estuaries. Lake Okeechobee is completely surrounded by the HHD. All of its inflows (except for Fisheating Creek) and outflows are controlled by an extensive system of levees, canals, water control structures, and large pump stations. During the wet season, the surface area of the lake extends to the dike on all sides of the lake. The maximum surface area is approximately 1,730 km², though the volume of the lake increases with depth. During the dry season, the surface area decreases considerably.

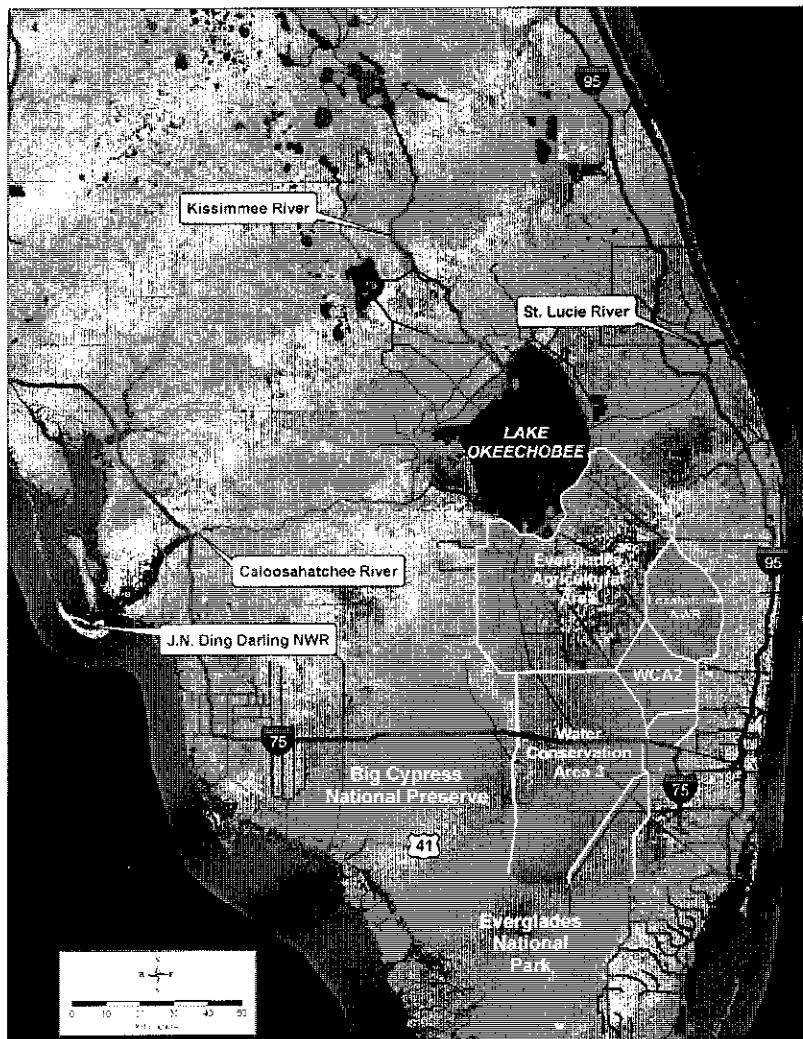


Figure 1. Lake Okeechobee Study Area.

The 12,000 km² Kissimmee River basin that flows into Lake Okeechobee lies north of the lake, and is dominated by dairy and beef operations. The 2,800 km² EAA is south of the lake, where water from the lake supports sugar, rice, and winter vegetable crops. The St. Lucie estuary is located northeast of Lake Okeechobee, and is connected to the lake by the St. Lucie canal (C-44), which discharges into the South Fork of the estuary. The estuary flows into the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet. The Caloosahatchee estuary is located southwest of Lake Okeechobee on the Gulf coast. The Caloosahatchee River (C-43) extends from Lake Okeechobee to the Franklin Lock and Dam (S-79) where it empties into the estuary.

There are six constructed wetlands known as stormwater treatment areas (STAs) downstream of Lake Okeechobee. The purpose of the STAs is to treat water from Lake Okeechobee prior to releasing it south into the WCAs. Since 1994, these constructed wetlands have reduced the total phosphorus load that would have gone into the Everglades by over 600 metric tons (District

2006a). Lake Okeechobee will contribute a significant portion of the water anticipated to be captured and treated in the STAs. A better understanding of the temporal and spatial characteristics of the water leaving the lake is needed for updated STA performance projections (District 2006a).

Because of the integrative nature of the regional system, management of the STAs is critical to providing water quality improvements. In addition, the District anticipates that all future Lake Okeechobee releases, whether they are pursuant to the Lake Okeechobee regulation schedule, Best Management Practices in the EAA, replacement water, or for water supply to downstream receiving areas, will be directed through the existing STAs prior to discharge to the Everglades Protection Area, when practical (District 2006a). Because of the critical nature of managing the STAs to ensure water quality criteria are met, the TSP for the Lake Okeechobee regulation schedule will take into account the general operational principles that are currently in place for the STAs.

2. Ecological Description

Pre-development Lake Okeechobee was considerably larger in surface area, with a littoral zone that extended over a wide expanse of low-gradient land to the north, west, and south of the lake's open water region (Havens et al. 1996a). The marsh and swamps that once surrounded the lake are now separated from the lake ecosystem by the HHD, and have been converted to urban and agricultural land uses. Today's remaining 400 km² littoral zone is a unique wetland that has been formed since impoundment of the lake. Lake Okeechobee is a critical concentration point for winter waterfowl along the Atlantic flyway and supports feeding and nesting of wading birds. The southwestern littoral zone of the lake comprises part of the critical habitat of the endangered Everglade snail kite.

3. Fish and Wildlife Resources

a. Federally Listed and Candidate Species

The Service identified seven federally listed species that occur within the area of effect for this project. A forthcoming BO for this project will evaluate the effects of the recommended plan on the:

- Everglade snail kite (*Rostrhamus sociabilis plumbeus*)
- wood stork (*Mycteria americana*)
- bald eagle (*Haliaeetus leucocephalus*)
- West Indian manatee (*Trichechus manatus*)
- Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*)
- eastern indigo snake (*Drymarchon corais couperi*)
- Okeechobee gourd (*Cucurbita okeechobeensis* ssp. *okeechobeensis*)

In addition to those species regulated by the Service, we have encouraged the Corps to consult with the National Marine Fisheries Service regarding possible effects of the project on sea turtles

in both estuaries, and Johnson's seagrass (*Halophila johnsonii*) within the St. Lucie estuary and/or Indian River Lagoon.

b. State-listed Species

The following species are listed by the State of Florida and are expected to occur in the project area:

- American alligator (*Alligator mississippiensis*)
- roseate spoonbill (*Ajaia ajaja*)
- limpkin (*Aramis guarauna*)
- little blue heron (*Egretta caerulea*)
- reddish egret (*Egretta rufescens*)
- snowy egret (*Egretta thula*)
- tricolored heron (*Egretta tricolor*)
- white ibis (*Eudocimus albus*)
- Florida sandhill crane (*Grus canadensis pratensis*)
- brown pelican (*Pelecanus occidentalis*)
- black skimmer (*Rynchops niger*)
- Florida pine snake (*Pituophis melanoleucus mugitus*)

c. Other Fish and Wildlife Resources

Lake Okeechobee provides habitat for fish and wildlife resources of direct monetary value (commercial and recreational fisheries, waterfowl hunting, alligator hunting) and of inestimable indirect value in terms of tourism, quality of life, and the survival of many threatened, endangered, and rare species. Furse and Fox (1994) estimated the value of five different vegetative communities in the lake in supporting the commercial and recreational fisheries, which they then estimated to have a "total economic value" in excess of \$480 million. The economic benefits of a healthy lake ecosystem on non-consumptive recreational activities in the lake may be more difficult to measure, but are increasing. Examples of non-consumptive uses of the lake include airboat tours, birding expeditions, and educational field trips.

IV. FISH AND WILDLIFE RESOURCE CONCERNS

A. Introduction

Lake Okeechobee is the heart of the water management system of central and south Florida, and the lake's regulation schedule has implications for fish and wildlife values throughout south Florida. Adverse effects of drought or wet seasons with extremely high rainfall can affect the lake for either short periods or for durations of two or more years. Regulatory releases from the lake can have dramatically adverse consequences in the St. Lucie and Caloosahatchee estuaries, but as explained below, water management in the drainage basins of the estuaries also contributes to ecological problems within the estuaries. The influence of water management in

the lake can also affect hydropatterns in the Everglades. The Lake Okeechobee conceptual model (Havens and Gawlik 2005) demonstrates the complex interactions among various environmental stressors affecting the lake. Therefore, division of the discussion into the following subsections of the report describing the Service's resource concerns is somewhat artificial, due to the high level of interaction among many of these factors.

B. Resource Concerns

1. Direct Effects of Lake Stages on the Lake Okeechobee Littoral Zone

The littoral zone of Lake Okeechobee is highly productive, sustains a great diversity of fish and wildlife, and is the area most affected by changes to the lake's regulation schedule. Changes in water depth and the duration of inundation control the vegetative communities of the littoral zone, the total area of the lake available as habitat for aquatic animals, and the availability of aquatic prey for higher consumers, particularly wading birds. Havens et al. (1996b) found that the littoral zone had a greater trophic complexity than open water habitats. Many of the additional species in the littoral zone that are not found in the pelagic zone are large predators (14 species of adult fish and 14 species of birds), but the majority of the additional taxa (54) are macroinvertebrates. The effects of water regulation in the lake on phytoplankton, periphyton, and benthic invertebrates are passed through the food web to readily observable losses in biodiversity at higher trophic levels.

During periods of extreme high lake levels (>17 ft), wind and erosion cause emergent and submerged plants to be torn loose from their substrates, resulting in a loss of important fish and wildlife habitat. When lake levels exceeded 17 ft in 1995 and 2004, large sections of bulrush (*Scirpus californicus* and *S. validus*) were lost. These plants occur at the interface between the pelagic and littoral zones where they are exposed to wave action, and constitute prime habitat for largemouth bass (*Micropterus salmoides*) and black crappie (*Pomoxis nigromaculatus*), two of the most important recreational fishes in the lake (Furse and Fox 1994). Following the drought of 2000-2001, the largemouth bass population began to recover after 3 years, due to the delay in re-colonization by SAV (Havens et al. 2005).

Extremely low lake levels (<11 ft) expose 95 percent of the littoral zone to desiccation, rendering the majority of the area unavailable as habitat for fish and waterfowl. One of the aquatic communities that becomes dry when the lake is at 11 ft is dominated by spike rush (*Eleocharis cellulosa*). This community is of particular concern because it supports a large population of apple snails, the primary food resource for the endangered snail kite. Spike rush is particularly valuable habitat for foraging snail kites because its moderate stem density accommodates the kite's visual hunting behavior. Maintaining clear water, sandy-bottom littoral habitat with emergent vegetation is necessary to support a healthy apple snail population (Darby et al. 2004).

As damaging as low water elevations are to the lake's littoral ecosystems, excessively high water elevations can be even more destructive. Steinman et al. (2002) list five possible ecological effects from extended periods of high water levels within Lake Okeechobee:

- Less light reaches the bottom of the lake, resulting in loss of submerged vegetation;
- Increased turbidity results in light limitation of bulrush (*Scirpus* spp.), which may weaken the plants, making them more susceptible to uprooting by wind-driven waves;
- Increased phosphorus concentrations in the nearshore regions, as phosphorus-rich sediments are transported from the central mud zone toward the littoral zone;
- Internal waves within the lake's water column spread sediments from the center of the lake to shoreline areas where much of the lake's submerged plants and fish/wildlife habitat occur; and
- Possible reduced rate of spread of invasive species in the lake's marsh zone, such as torpedo grass (*Panicum repens*) and *Melaleuca quinquenervia*, both of which can tolerate flooded conditions, but appear to increase in coverage following dry conditions.

In addition to the detrimental effects that occur from the short-term extreme events, the lake was subjected to the 15.5 ft to 17.5 ft water regulation schedule from 1978 to 1992. This regulatory period demonstrated the deleterious effects of a prolonged period of moderately high lake stages. Milleson (1987) documented vegetation changes along the Moore Haven and Indian Prairie transects in the littoral zone, as compared with conditions found by Pesnell and Brown (1977). Milleson found a loss of spike rush, an expansion of cattail (*Typha domingensis*), and invasion by the exotic torpedo grass. Torpedo grass is poor habitat and cannot support the fish and wildlife populations that are found in native vegetation. Milleson attributed these changes to prolonged inundation of the littoral zone by stages over 15 ft with the 15.5-17.5 ft regulation schedule, which had then been in effect since 1978. He predicted that reduced diversity of the marsh vegetation would adversely affect waterfowl, wading birds, reptiles, fish, and other species that depend on a diverse marsh.

On the basis of Milleson's observations and subsequent evaluations of littoral zone vegetation (Richardson and Harris 1995; Richardson et al. 1995), the Service believes that prolonged periods of lake stages over 15 ft favor less diverse, more permanently flooded wetland communities, rather than the more diverse vegetation produced in alternately flooded and exposed portions of the littoral marsh. The reduction in the proportion of the littoral zone vegetated by willow (*Salix caroliniana*) in the early 1970s has been attributed to higher lake stages (Richardson and Harris 1995; Richardson et al. 1995). Willows are important nesting sites for the endangered snail kite and several species of wading birds. David (1994a, 1994b) found that by 1988 wading birds no longer nested in the willows at the King's Bar colony, which contained nearly 10,000 nests in 1974 and 6,000 nests in 1978 (excluding cattle egret [*Bubulcus ibis*]). He attributed this loss of the larger nesting colonies to implementation of the 1978 regulatory schedule.

In addition to the adverse effects on wading bird nesting habitat due to changes in vegetation, several studies indicate additional adverse effects of sustained high lake stages on feeding by wading birds. Zaffke (1984) found that successful wading bird feeding in the littoral zone

depended on receding lake stages below 15 ft and suggested that the 15.5-17.5 ft schedule, was detrimental to feeding and nesting wading birds. This observation has been supported in subsequent studies by Smith et al. (1995) and Smith and Collopy (1995).

Bull et al. (1995) found significant negative correlations between water depth at sample sites in the lake's pelagic zone and the abundance of threadfin shad (*Dorosoma petenense*) and bluegill (*Lepomis macrochirus*), while increased depth was positively correlated with abundance of white catfish (*Ameiurus catus*) and black crappie (*Pomoxis nigromaculatus*). Additional study is needed on the effect of lake stage on the standing stock and reproductive success of fishes in the littoral zone.

2. Minimum Flows and Levels for Lake Okeechobee

Florida law requires the water management districts to establish Minimum Flows and Levels (MFLs) for surface waters and aquifers within their jurisdiction (section 373.042(1), *Florida Statute [F.S.]*). The minimum level is defined as the "limit at which further withdrawals would be significantly harmful to the water resources of the area." Section 373.0421(2), *F.S.*, provides that if it is determined that water flows or levels will fall below an established MFL within the next 20 years or is presently below the MFL, the water management district must develop and implement a recovery or prevention strategy.

In addition to low-water effects on water supply and navigation, significant harm may also occur to the lake's littoral zone when lake levels fall below 11 ft. When lake levels drop to 11 ft, approximately 94 percent of the littoral marsh is dry and no longer functions as habitat for fish and other aquatic-dependent wildlife (District 2000a). Also, the spread of invasive species such as torpedo grass and *Melaleuca* is facilitated by long periods of dry littoral marsh. The western littoral zone of Lake Okeechobee is important habitat for the Everglade snail kite, and is designated as critical habitat. Apple snails within the littoral zone can tolerate dry-outs of short duration outside of their peak breeding season (April-May), but extremely low water levels for long durations, particularly during their breeding season, will impact the snail population (Darby et al. 2003; 2004), and therefore affect foraging and reproduction of the snail kite.

The MFL for Lake Okeechobee is currently defined as:

The water level in the lake should not fall below 11 ft for more than 80 days duration, more often than once every 6 years, on average (District 2000a).

The Service believes that this definition is a good estimate of what would constitute significant harm to the ecological integrity of the lake. While we do not focus on single species management, the importance of maintaining a healthy apple snail population is critical for ensuring the suitability of the snail kite's critical habitat and nesting success within Lake Okeechobee. This MFL target can act as a surrogate measure of the lake's suitability for apple snail habitat, in addition to other ecological concerns.

3. Effects of Lake Stage on Water Quality in the Lake

Havens (1997) provides a review of ecological changes in Lake Okeechobee caused by cultural eutrophication and discusses the relationships between higher lake stages and increased total phosphorus concentrations in the pelagic zone of the lake. Janus et al. (1990) and Maceina (1993) hypothesize that higher lake stages increase the incidence of algal blooms. An algal bloom in August 1986, covering 300 km², caused the death of thousands of apple snails in the western littoral zone of the lake, part of the designated critical habitat for the endangered snail kite.

The concentration of total phosphorus in the lake nearly doubled from 49 parts per billion (ppb) in 1973 to 98 ppb in 1984 (Janus et al. 1990). Despite progress in reducing phosphorus loading rates to the lake through implementation of Best Management Practices in dairies north of the lake, the phosphorus loading exceeds the legally-mandated Surface Water Improvement and Management plan target. The Lake Okeechobee Protection Act provides substantial cost sharing incentives to farmers within the Kissimmee basin and, since 2002, many water quality improvement projects have been implemented within the Lake Okeechobee watershed.

The water column phosphorus concentration goal for the lake is 40 ppb (District 2006b). At present, the concentration of phosphorus in the lake averages 214 ppb, with an average of 158 ppb over the past 5 years (District 2006b), partly due to the high inputs from river sediments, but mostly from re-suspension of lake sediment from the hurricanes in 2004 and 2005 that had yet to settle out. Even with reduction of phosphorus loading from external sources, internal phosphorus loading from re-suspension of phosphorus-rich sediments that have built up in the lake may affect water quality in the lake for several decades (Havens et al. 1996a; Steinman et al. 1998). The result from the four hurricanes in 2004 was a total volume of inflows and rainfall to the lake for the 3 months (August–October 2004) of 3.2 million acre-feet (af), which is close to an average water year in total volume inflow. This large inflow resulted in high loads of phosphorus, with approximately 792 metric tons of phosphorus being added in these 3 months alone (District 2006a).

Warren et al. (1995) found that the benthic invertebrate communities of Lake Okeechobee's sublittoral zone are of relatively poor quality and that shifts toward dominance of more undesirable species (indicative of highly eutrophic conditions) have occurred at a rapid rate. Higher lake stages are likely to increase the transport of nutrient-rich water from the pelagic zone to the littoral zone, which would ultimately reduce the diversity of the invertebrate community in the littoral zone, which has a higher diversity of benthic invertebrates than the sublittoral zone (Havens et al. 1996b).

Havens and James (1999) suggest that observed declines in water transparency could be explained by the migration of mud sediments from mid-lake towards the littoral zone along the southwestern shore. This migration of sediment would be more likely to occur under extended periods of high water and could have severe impact on the primary productivity of the littoral zone. The reduction in water clarity, which is more likely to occur with a combination of high average water stages and storms, can have an adverse effect not only on SAV, but also the

extremely important periphyton community. Similar to the Everglades, a healthy littoral zone in Lake Okeechobee sustains periphyton, which is a nutritious food base for grazing invertebrates and fishes, such as grass shrimp (*Palaemonetes paludosus*), apple snails, flagfish (*Jordanella floridae*), and sailfin mollies (*Poecilia latipinna*). These fish and invertebrates rely on the primary production of periphyton and form a key linkage in the food chain to commercially and recreationally important fish and wildlife. In addition to loss of bulrush stems on the outer edge of the littoral zone during the extended high water event of 1994 to 1995, the remaining bulrush has been largely lacking periphyton (Fox 2007) apparently because of a combination of physical scouring of the stems and the lack of light penetration, both of which can be correlated with high water levels. The increased turbidity following the 2004 and 2005 hurricanes has also apparently retarded regrowth of periphyton on the stems of emergent vegetation that survived physical damage from the storms.

4. Spread of Exotic Vegetation in the Littoral Zone

The conceptual ecological model for Lake Okeechobee indicates that extremely low water stages may favor expansion of exotic vegetation. The Service finds that although water regulation certainly is one of several variables influencing spread of exotic vegetation, the magnitude of this variable relative to others has not been clearly documented.

The spike rush habitat in Moonshine Bay (preferred foraging habitat for the snail kite) is encircled by the exotic torpedo grass, which may overtake the region if low water levels suppress the growth and survival of the native plants. Torpedo grass is tolerant of a much wider range of hydroperiods, and appears to thrive under both wet and dry conditions (Sutton 1996). Torpedo grass is poor habitat and cannot support the fish and wildlife populations that are found in native vegetation. However, Smith et al. (1995) suggest that once every several years, allowing the lake stage to drop to 10 to 12 ft in the dry season would be beneficial to wading bird populations, "to expose prey-rich submerged beds, invigorate essential willow stands, and to allow fires to burn away cattail and *Panicum* wrack, recycle nutrients, and encourage establishment of attractive successional vegetation complexes." The current set of performance measures produce unfavorable scores when lake stages drop below 11 ft. The Service does not agree at this time with Smith et al. (1995) regarding the recommendation to drop water levels below 11 ft on a regular basis, but we support controlled burning in the littoral zone whenever natural droughts allow it. Research is needed to determine the consequences of such a management strategy relative to expansion of exotic vegetation and overall diversity and productivity of the littoral zone.

Smith et al. (1995) state that *Melaleuca* expanded its range in Lake Okeechobee following the 1989-90 drought, displacing some areas of more productive spike rush and beak rush (*Rhynchospora*) flats. However, based on experiments in mesocosms subjected to varied hydroperiods, Lockhart et al. (1999) found that a lower lake regulation schedule may not stimulate expansion of *Melaleuca*. They found that although *Melaleuca* is affected by hydroperiod, it is highly adaptable to a wide range of environmental conditions, and that water management is not the most effective management alternative to control this exotic species.

They recommend continuation of the ongoing chemical treatment of *Melaleuca*, with introduction of biological controls, as a more effective management strategy.

5. Effects of the Lake Okeechobee Regulation Schedule on the St. Lucie and Caloosahatchee Estuaries

The Lake Okeechobee regulation schedule can have a direct effect on estuarine health due to the relationship between regulatory lake releases and the salinity within the estuaries. Maintaining the desired salinity within the estuaries is a delicate balance, with seasonal and historical fluctuations that support a wide range of salt-tolerant plant and animal communities. During the dry season, freshwater flow to the estuaries is reduced, or even eliminated, which results in a rise in salinity within the estuarine systems. For the St. Lucie estuary, local basin runoff is enough to maintain minimal freshwater input into the estuary, except in the driest years, but the Caloosahatchee estuary depends on fresh water releases from Lake Okeechobee to maintain a healthy ecosystem during the dry season, particularly during drought conditions. Conversely, during the wet season, excessive flows of fresh water from the lake to the estuaries lower the salinity within the estuaries to damaging, and sometimes destructive, levels. Current performance measures use freshwater flow volumes as a surrogate measure for desirable salinity conditions within the estuaries. We recommend future revisions of the regulation schedule also include evaluation of nutrient (phosphorus and nitrogen) concentrations and loading to the estuaries.

Caloosahatchee Estuary

Major environmental concerns for the Caloosahatchee estuary and San Carlos Bay include altered fresh water inflows, extreme variation in salinity levels, and eutrophication, all of which can be attributed to excessive releases of fresh water flows from Lake Okeechobee and runoff from the Caloosahatchee River drainage basin. The river has undergone a number of hydrological modifications, often with environmental consequences (Haunert et al. 2000), to facilitate navigation, flood control, and lake regulatory releases. Such modifications have dramatically altered the natural quantity, quality, timing, and distribution of freshwater flows to the estuary and created extreme fluctuations in salinity levels.

The Caloosahatchee River was originally a shallow, meandering river with headwaters in the proximity of Lake Flirt (Kimes and Crocker 1998) and probably only rarely received water from outside its watershed or from Lake Okeechobee except during extreme regional flooding events. The river was connected to Lake Okeechobee in 1881 as an attempt to lower the lake's water table (Kimes and Crocker 1998). The river now functions as a primary canal (C-43) that serves as a major outlet for regulatory releases from Lake Okeechobee to the Gulf of Mexico, and drains an area of about 1,327 square miles. Wet season runoff that was historically retained within the undeveloped Caloosahatchee watershed now reaches the river in greater volume and less time through an intricate canal system (Corps 1957) and is often compounded by lake releases.

Three locks and dams were constructed to control flow and stage height in the river. The most downstream structure, the W.P. Franklin Lock and Dam (S-79), marks the beginning of the

Caloosahatchee Estuary. The S-79 structure maintains specific water levels upstream, regulates freshwater discharge into the estuary, and acts as an impediment to saltwater intrusion and tidal action which historically extended far upstream. Thus, S-79 truncates the estuary and now spatially limits the dry season oligohaline (*i.e.*, freshwater and low salinity brackish water) zone of the estuary, as well as the free passage of organisms seeking refuge, nursery, and breeding areas characteristic of this zone (Chamberlain and Doering 1998a, 1998b; Doering et al. 2002; District 2002).

The natural and historic gradient of salinity zones within the Caloosahatchee Estuary and San Carlos Bay serve as important nursery, feeding, and refugia areas for juvenile stages of desirable sport and commercial fishes. At least 70 percent of Florida's recreationally sought fishes depend on estuaries for at least part of their life histories (Harris et al. 1983; Estevez 1998; Lindall 1973). Excessive variation in fresh water flows and salinity maintain estuarine biota in a constant flux between those favoring higher salinity and those favoring lower salinity (Bulger et al. 1990). Optimal salinity conditions may not last long enough for organisms to complete their life cycle and the estuary can become devoid of some populations, even keystone species that support major ecosystem components along an estuary's salinity gradient such as fresh and salt water SAV and/or oysters.

Depending on day of the year, the long-term mean daily discharge at S-79 ranges between 300 cubic feet per second (cfs) and 3,000 cfs. However, daily and monthly inflows often exceed this long-term average particularly during the wet season, with prolonged inflows commonly exceeding 4,500 cfs lowering salinity levels in the San Carlos Bay area and the J.N. "Ding" Darling National Wildlife Refuge (NWR). Flows that reach above this threshold (occasionally exceeding 10,000 cfs) can push freshwater into Pine Island Sound and the Gulf of Mexico, thus impacting ecologically and commercially important high-salinity marine resources that historically were not directly affected by Caloosahatchee River discharges. During the dry season, the combination of limited rainfall, lack of water storage in the basin and withdrawals to meet human demands for irrigation and potable water often results in periods of no freshwater discharge to the estuary. Saltwater can intrude all the way upstream to S-79 threatening species that require low salinity to complete their life cycle (Chamberlain and Doering 1998a, 1998b; Doering et al. 2002; District 2002).

Tape grass (*Vallisneria americana*) is the dominant SAV in the upper Caloosahatchee estuary including the 40-acre Caloosahatchee NWR and occurs in well-defined beds in shallow water. Tapegrass is an important habitat for a variety of freshwater and estuarine invertebrate and vertebrate species, including some commercially and recreationally important fishes (Bortone and Turpin 1999) and migratory waterfowl. During times of extended low inflow conditions, when salinity is too high, tape grass becomes sparse and can disappear completely (Chamberlain et al. 1995; Doering et al. 2002; District 2000b). Preliminary analysis suggests that a minimum inflow of 300 cfs during the dry season will promote the growth of *Vallisneria americana*.

A substantial loss in the extent of seagrass coverage has occurred in the lower estuary (Harris et al. 1983). Each species of SAV has a specific temperature and salinity tolerance range and their tolerance towards variations in salinity are similar to their tolerances for temperature.

Furthermore, estuarine biota is well adapted to and depends upon natural seasonal changes in salinity. When salinity falls outside of these normal and seasonal ranges, it may result in a reduction in densities and shifts in distribution of SAV species and organisms dependant upon these productive habitats (Chamberlain and Doering 1998b).

Shoal grass (*Halodule wrightii*) is the only seagrass species consistently located in the lower estuary upstream of Shell Point until it mixes downstream with turtle grass (*Thalassia testudinum*) in San Carlos Bay. Although shoal grass has a wide salinity tolerance (McMahan 1968), high freshwater inflows (*i.e.*, greater than 3,000 cfs) from S-79 influence its distribution and density (Chamberlain and Doering 1998b; Doering et al. 2002). Shoal grass tolerates salinity as high as 44 parts per thousand (ppt); however, its productivity decreases when salinity falls below 20 ppt and it does not survive when salinity drops below 3.5 ppt for extend periods (*i.e.*, 30 days or more) (Zieman and Zieman 1989). This wide tolerance is probably why it is the only true seagrass species encountered upstream of Shell Point where salinity is lower and more variable than in San Carlos Bay (Chamberlain et al 1995; Chamberlain and Doering 1998b; Doering et al. 2002). Accordingly, shoal grass biomass is lower above Shell Point than in downstream areas where salinity is above 20 ppt more consistently.

Turtle grass does not grow in areas with salinity normally below 17 ppt and will suffer significant leaf loss when exposed to lower salinity. The maximum productivity of turtle grass occurs in full strength seawater and decreases proportionately with decreasing salinity. The optimum salinity range for turtle grass is 24 to 35 ppt (Zieman and Zieman 1989). Thus, turtle grass does not exist upstream of Shell Point where salinity is more variable.

Extremely high fresh water flows to the Caloosahatchee estuary occurred for extended time periods during the 2004 and 2005 hurricane seasons causing a reduction in density and cover of seagrass beds in the estuary, extending into San Carlos Bay and the J.N. "Ding" Darling NWR. Additionally, lake releases carried high nutrient levels from bottom sediments that were re-suspended by the hurricanes. Harmful algal blooms occurred in the Caloosahatchee River and estuary following periods of high regulatory releases from Lake Okeechobee causing public concern.

Salinity is also important in determining the distribution of coastal and estuarine bivalves, such as oysters. Short pulses of freshwater inflow can greatly benefit oyster populations by killing predators, while excessive freshwater inflows may kill entire populations of oysters (Gunter 1953; Schlesselman 1955; MacKenzie 1977). Although a substantial oyster population still exists within the lower Caloosahatchee estuary, historical accounts of the river indicate that oysters were once more prominent (Sackett 1888). As individual oysters die they leave empty compartments for various estuarine residents. Volety et al. (2003) found that a greater abundance of decapods and fishes were associated with clusters of live oysters compared to dead-articulated clusters, while the structure provided by both living and dead oyster shells supported a greater abundance of these estuarine organisms than no shells at all.

Oysters in southwest Florida spawn continuously, with peak recruitment (spat settlement) occurring during May to November. Recruitment at these times is often threatened by large freshwater inflows through S-79 (*i.e.*, greater than 4,000 cfs), a portion of which can be attributed to the need to regulate Lake Okeechobee. These freshwater flows expose oyster larvae to lethally low salinities (*i.e.*, 5 ppt or less) or flush the larvae to more downstream locations where there may not be suitable substrate for settlement (Volety et al. 2003).

The District conducted research in the Caloosahatchee estuary focusing on the impacts associated with the extreme variability in freshwater inflow from S-79 (Chamberlain and Doering 1998a). The purpose of the research was to determine the proper timing and volume of water quantity required to support valued ecosystem components, including submerged freshwater and marine grasses and oysters, as well as the impacts of flows on general biotic indicators, such as fish, plankton and benthic invertebrates (District 1998). This research resulted in the development of optimum S-79 flow ranges and delivery patterns for the estuary (Chamberlain and Doering 1998b; Doering et al. 2002; Volety et al. 2003). The information has formed the basis for development of hydrologic performance measures to evaluate alternatives for this study, the Comprehensive Everglades Restoration Plan, and the Southwest Florida Feasibility Study, as well as meeting legislative mandates for the development of salinity criteria for the establishment of the Caloosahatchee River and estuary MFL (District 2000b, 2003).

The MFL salinity criteria were initially designed to protect tape grass upstream of Ft. Myers but are also beneficial for other organisms that utilize this low salinity region of the estuary (Chamberlain and Doering 1998b; Doering et al 2002). The MFL study indicated that the proposed criteria for the Caloosahatchee River and Estuary will be exceeded on a regular and continuing basis until additional storage is provided in the basin to supply the additional water needed. Although the currently proposed changes to the regulation schedule do not include additional water storage in the system, the study team attempted to increase the period of time in which the MFL criterion could be met.

These criteria and performance measures were derived from relationships between the distribution, abundance, growth and survival of estuarine organisms and changes in salinity or freshwater discharge. Salinity tolerances of submerged grasses were initially used to identify minimum and maximum inflows at S-79. Mean monthly flows less than 300 cfs are thought to allow salinity in the upper estuary to exceed the tolerance of tape grass. Flows greater than 2,800 cfs depress salinity in the lower estuary and threatens the marine shoal grass typical of this region (Chamberlain and Doering 1998b; Doering et al. 2002). Research has shown that flows at S-79 within this range are beneficial to other estuarine organisms (*i.e.*, fish, zooplankton, ichthyoplankton, shrimp, crab, oysters, and benthic invertebrates) as well, and that flows greater than 2,800 cfs may also be detrimental to those biota (Chamberlain and Doering 1998a, 1998b; District 2003; Volety et al. 2003). Therefore, a distribution of inflows that range from 300 to 1,500 cfs, with a peak of 300 to 800 cfs, should be generally beneficial to the biota of the estuary (Chamberlain and Doering 1998a, 1998b; District 2003).

St. Lucie Estuary

The ecological conditions within the St. Lucie estuary are very similar to those experienced by the Caloosahatchee in terms of damage to estuarine plant and animal communities. Ecological harm from high flows to the St. Lucie estuary during the 1997-1998 El Niño event and during the 2004-2005 hurricane seasons caused serious concern. The North Fork of the St. Lucie River, which normally averages 18 ppt salinity decreased to 0 ppt during peak flows. Portions of the St. Lucie estuary that normally average 24 ppt decreased to 5 ppt, and the Indian River Lagoon, which normally averages 30 ppt, decreased to approximately 20 ppt. The high volume freshwater discharges coincided with a high incidence of fish with lesions and public health warnings.

In addition to the deleterious effect that freshwater releases from Lake Okeechobee has on salinity, other direct impacts on the water quality of the estuary are experienced, including conveyance of silts, sediments and other pollutants to the estuary. Because of local runoff from agricultural and urban development within the watershed, even in the absence of Lake Okeechobee discharges, the desirable salinity envelope of the estuary is often exceeded by too much fresh water entering the estuary.

6. Effects of the Lake Okeechobee Regulation Schedule on the Arthur R. Marshall Loxahatchee National Wildlife Refuge

Water Conservation Area 1 (WCA-1) operates on state-owned land managed by the Service under a license agreement with the state of Florida as the Arthur R. Marshall Loxahatchee National Wildlife Refuge (A.R.M. Loxahatchee NWR). WCA-1 has three primary uses: flood protection, water supply (to the Lake Worth Drainage District, and also Broward and Palm Beach Counties), and the natural environment. Water elevations within WCA-1 are governed by a regulation schedule similar to that used for Lake Okeechobee. Ground level elevations within WCA-1 range from 17 ft at the northern end to 12 ft at the southern end. The current operational minimum water level as described by the regulation schedule (Corps 1995) is 14 ft within the perimeter canal.

When the water level within WCA-1 is in Zone B of its regulation schedule, water supply releases are not permitted unless an equal amount of water is first supplied to WCA-1 from Lake Okeechobee as preemptive replacement water. This replacement water can be supplied to WCA-1 only when the water elevation within Lake Okeechobee is no more than 1.0 ft lower than the water elevation in WCA-1. Water supply withdrawals can continue until the water elevation within WCA-1 drops below 14 ft. At that point, temporary deviations from the regulation schedule may be approved to allow water supply withdrawals to continue below the 14 ft elevation. If the water elevation within Lake Okeechobee is more than 1.0 ft lower than the water elevation in WCA-1, then it is no longer required that replacement water be released from the lake to WCA-1, and all further water supply withdrawals therefore constitute a net loss of water to WCA-1.

Managing Lake Okeechobee at lower levels may reduce preceding inflow events to WCA-1 because of an increased likelihood of the difference between the lake and WCA-1 stages being

greater than 1 ft. As a result, reducing the number of preceding inflow events to WCA-1 may translate into drier conditions with WCA-1 and also increase the likelihood of deviation requests by water users to go below the 14 ft floor for water supply purposes.

Overall, lower water levels within Lake Okeechobee have the potential of exacerbating stressful ecological conditions within WCA-1 during the dry season. Chronic and frequent events below the 14 ft floor may:

- Increase the expansion of invasive species;
- Facilitate the undesirable conversion of slough and wet prairie habitats to sawgrass and shrub habitats;
- Decrease habitat suitability for fish populations;
- Potentially reduce nesting and foraging options for wading bird populations;
- Increase the likelihood of severe wildland/muck fires; and
- Influence how the marsh responds to re-wetting events when stage and/or rainfall increases during the beginning of the rainy season.

C. Summary/Planning Objectives

With a wide variety of resource concerns dependent upon the effectiveness of the lake's regulation schedule, the planning objective for this project was to balance these resource needs against one another, and select a plan that best meets the goal of the project. As mentioned earlier in this report, the Corps altered the emphasis of its planning objectives, favoring flood protection (integrity of the HHD) over the originally stated environmental improvement objectives. Consequently, when considering the proposed alternatives, more weight was given to maximizing the flood control capacity of the lake. The PDT collectively evaluated the environmental benefits of each alternative within this constraint.

V. EVALUATION METHODOLOGY

Experts on Lake Okeechobee operations and the South Florida Water Management Model (SFWMM) began the development of alternative plans for evaluation by the PDT in early 2006. The SFWMM was designed to simulate the hydrology and management of south Florida water resources from Lake Okeechobee south to Florida Bay. Model output was run through performance measures resulting in large amounts of comparative data for evaluation by the PDT. Throughout the evaluation process, many of the alternatives were modified to improve their performance and to account for changes in model assumptions, resulting in several tiers of alternatives. When evaluating each tier of alternatives, the agencies formed a consensus on which alternatives were worthy of further modification and evaluation, and which ones were to be dropped due to their failure to meet project goals and expectations.

Evaluations of the alternatives were made by comparing the modeling results for each alternative (as expressed in performance measure output) with the No Action alternative (2007LORS), and with each other. Those alternatives that performed far outside the range of the other alternatives, or which violated performance constraints were modified to improve their performance, or

eliminated from further review. Throughout most of the review period, team consensus was achieved to select which alternatives moved forward in the review process, though certain alternatives were carried through the evaluation to provide a broader array of alternatives to be considered for the National Environmental Policy Act evaluation (*e.g.*, Alternative 3).

When providing our input for the PDT review, the Service evaluated the alternatives using the following performance measures:

Caloosahatchee Estuary

- Number of Mean Monthly Flows <450 cfs
- Number of Mean Monthly Flows between 2,800 and 4,500 cfs
- Number of Mean Monthly Flows >2,800 cfs (from basin)
- Number of Mean Monthly Flows >2,800 cfs (from Lake Okeechobee)
- Number of Mean Monthly Flows >2,800 cfs (total)
- Number of Mean Monthly Flows >4,500 cfs
- Number of Mean Monthly Flows >4,500 cfs for >5 weeks
- Number of Mean Monthly Flows >4,500 cfs for >12 weeks *

St. Lucie Estuary

- Number of Mean Monthly Flows <350 cfs
- Number of Mean Bi-weekly Flows >2,000 cfs (from basin)
- Number of Mean Bi-weekly Flows >2,000 cfs (from Lake Okeechobee)
- Number of Mean Bi-weekly Flows >2,000 cfs (total)
- Number of Mean Monthly Flows between 2,000 and 3,000 cfs
- Number of Mean Monthly Flows >2,000 cfs
- Number of Mean Monthly Flows >3,000 cfs
- Number of Mean Moving 2-Week Flows >3,000 cfs for > 2 weeks *

Lake Okeechobee

- Low Stage < 11 ft
- Low Stage < 11 ft for > 80 days
- Low Stage < 12 ft for > 365 days
- Low Stage Number of Days < 12.56 ft
- High Stage > 15 ft for > 365 days
- High Stage > 17 ft
- High Stage > 17.25 ft for > 7 days *
- High Stage > 17.5 ft for > 7 days

* = used only in evaluations of the final set of alternatives

Additional performance measures were used by other PDT member agencies in their respective evaluations, and were discussed and considered during regular PDT meetings. The District conducted detailed evaluations of water supply, estuaries, Lake Okeechobee ecology, and the

greater Everglades ecosystem. The Corps focused primarily on certain issues, specifically, flood control, integrity of the HHD, and navigation.

Because the Service is primarily concerned with the ecological effects of the project, we looked closely at the Everglades evaluation performed by the District. They analyzed the performance measure output for peat dry-out, reversals, recessions, tree island inundation, and snail kites within the WCAs. All of these performance measures used model output from a representative sample of CERP Indicator Regions from WCA-1 (A.R.M. Loxahatchee NWR), throughout WCA-2 and WCA-3, and south to Shark River Slough in ENP.

VI. FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Without selection and implementation of the proposed TSP (Alt-T3), the current WSE regulation schedule would be maintained for 3 more years, until a new revision to the schedule is implemented in 2010. None of the final tier of alternatives evaluated for the project would be expected to improve performance across the full range of performance measures, even if we limit consideration to ecological performance measures, excluding flood control and water supply concerns. The TSP is the only alternative that strikes a more acceptable balance in environmental trade-offs than the existing WSE schedule. Under the present regulatory constraints, extreme high and low water stages, as have occurred over the past 6 years, cannot be entirely prevented regardless of which alternative is selected. The damages to the St. Lucie and Caloosahatchee estuaries and to Lake Okeechobee's littoral zone from high water events would likely be of slightly greater amplitude and/or duration with continuation of the WSE schedule, as compared to the TSP. However, impacts to Lake Okeechobee from low water events (such as drought) would likely be less with the No Action alternative than with the TSP. On balance, we believe that the TSP is the only alternative that is generally better than the No Action alternative in most of the resource areas of concern. The No Action alternative might be more favorable overall if the next 3 years include a severe or prolonged drought. Lowering the potential risks of high water on the HHD would be prudent if the next 3 years have higher than average precipitation. With years of high precipitation, the overall ecological benefits of reducing the duration and magnitude of high water stages would not be realized under the No Action alternative.

VII. DESCRIPTION OF SELECTED PLAN AND OTHER ALTERNATIVES

A. Selected Plan

The Corps has chosen Alternative T3 (also known as Alt1bS2-T3 or Alt-T3) as the TSP in the revised draft of the SEIS. The TSP for the initial draft of the SEIS, which was released for public review on August 10, 2006, presented Alt1bS2-m as the TSP. Due to large volume of negative feedback from the public regarding the poor performance of Alt1bS2-m, the Corps decided to reformulate the TSP in order to improve its performance, particularly with respect to high freshwater flows to the Caloosahatchee estuary. The final tier of alternatives was subjected to an additional round of modeling and new evaluations, with the opportunity to achieve

additional refinement in an iterative process. From these final alternatives, Alternative T3 was chosen as the new TSP.

Because this alternative is a derivative of earlier, competing alternatives, a stand-alone description of it would be difficult to comprehend without putting it into context of the overall linear development of the *Alt1b* series of alternatives. Consequently, refer to the following section for descriptions of all the alternatives, including the TSP.

B. Tiers of Alternatives

The project began with consideration of four basic alternatives: Alternative (Alt)1, Alt2, Alt3, and the No Action alternative (which is known as 2007LORS, or the future without project condition). After preliminary discussions between modelers, these alternatives were modified, and both Alt1 and Alt2 were split into two new versions, called Alt1a, Alt1b, Alt2a and Alt2b. These four, along with Alt3 and 2007LORS, comprised the initial tier of alternatives evaluated by the PDT.

The second tier of alternatives was composed of further modifications to Alternatives 1a, 1b and 2b, plus the addition of a fourth alternative called Alt4. Alt3 was dropped from further consideration because of poor performance, and this resulted in the following group of alternatives: Alt1aS1, Alt1aS2, Alt1bS1, Alt1bS2, Alt2a, Alt2b, Alt2bS1, Alt4 and 2007LORS.

After reviewing this alternative group, the decision was made to move only three of the proposed alternatives forward in the review process (in addition to the 2007LORS No Action alternative), and the PDT reached a consensus to select Alt1aS2, Alt1bS2 and Alt4 as the three final alternatives. Alt2a was added to this final tier at the insistence of the Corps, and Alt3 was also later added to the final tier, in deference to earlier public comments. This group was to be the final tier of evaluations prior to publication of the Draft SEIS, and selection of the TSP.

During the modeling and evaluation process for this tier of alternatives, further enhancements and constraints were imposed upon the alternatives, which went through several more iterations (known as sensitivity runs), and resulted in the following alternatives being evaluated by the Corps in their first Draft SEIS: Alt1bS2-A, Alt1bS2-m, Alt2a-B, Alt2a-m, Alt4-A and 2007LORS. The Corps then solicited input from PDT members, and chose Alt1bS2-m as the TSP.

After publication of the first Draft SEIS, the large volume of negative public comments on the proposed TSP prompted the Corps and the PDT to reformulate the TSP and evaluate a new set of alternatives. The new set of alternatives were all derived from Alt1bS2-A, and throughout this report are referred to as the final tier of alternatives. Please refer to Figure 2 for the lineage of the final array of alternatives. The PDT chose Alt-T3 as the new TSP, and this alternative was analyzed and presented in detail in the Corps' revised draft SEIS.

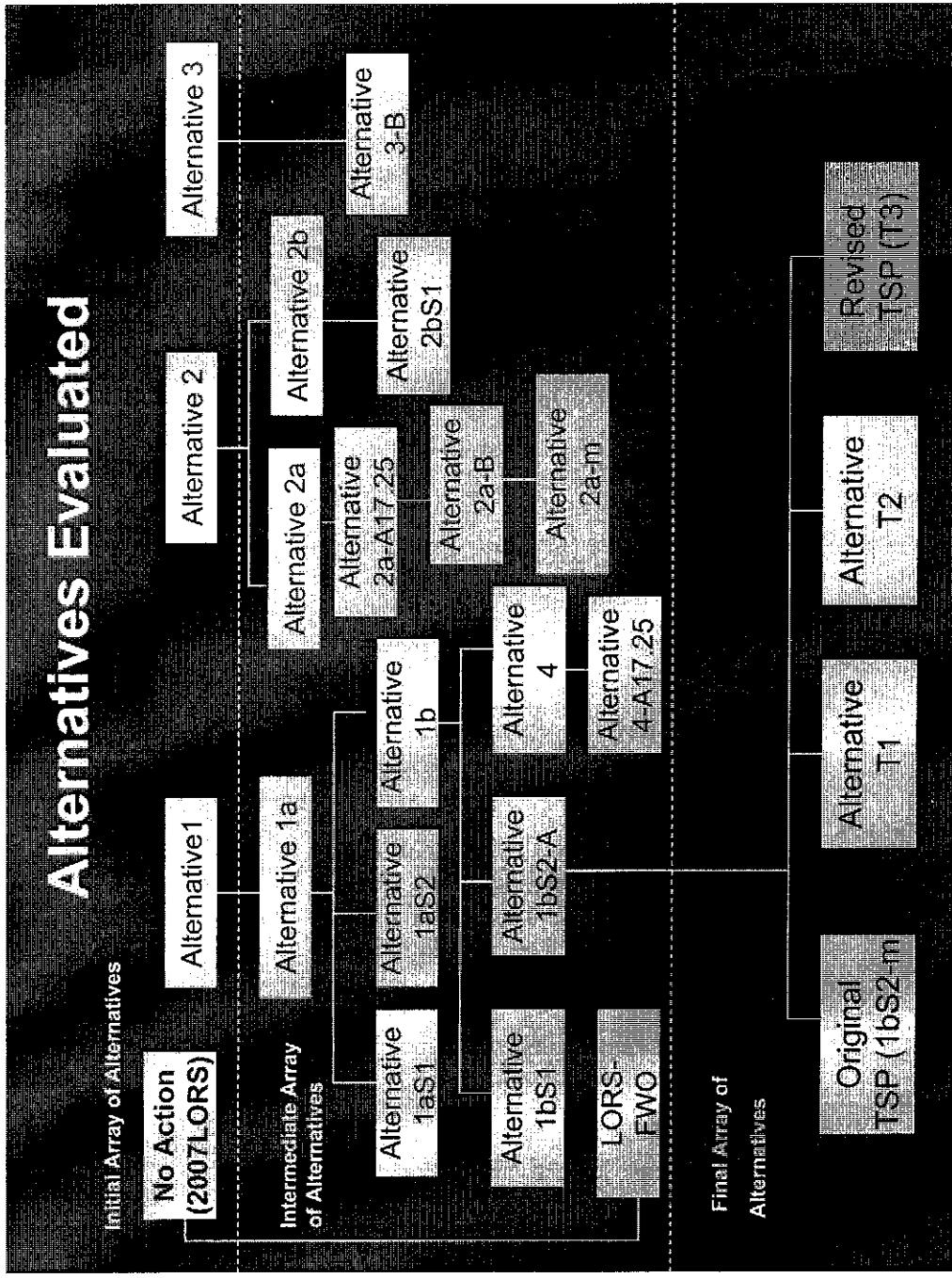


Figure 2. Final array of alternatives.

C. Alternative Descriptions

The goal of this project is to revise the regulation schedule for the operation of an existing infrastructure of water conveyance and control structures, and no new construction is proposed. Each alternative is a variation of operational rules to determine when, where, and how much water should be released from the lake to downstream systems. Alternatives can be depicted by charts and decision trees; describing them in a textual form is difficult. The following alternative descriptions are taken from the website maintained by the Corps for dissemination of information and modeling data related to this project (<http://hpm.sfrestore.org/loweb/sfwmm/>). For the most part the descriptions here are repeated verbatim from the Corps' website, with minor editorial changes made to remove extraneous information and improve readability. Please refer to referenced website, and to the Draft SEIS (Corps 2006) for further information on the development and refinement of the alternatives.

1. LORS Base Runs

The following describes the origin and evolution of the 2007LORS existing condition model run, as developed from the District modeling of the 2005 Lower East Coast Regional Water Supply Plan (LECRWSP).

2005BS

This is the input from the District for the Lower East Coast (LEC) 2005 base case (2005 LECRWSP).

2005LORS

This run was created from the above run with changes that better represent the Interim Operational Plan (IOP) operations. Based on modeling conference calls on February 6, 10, and 16, 2005, between Corps modelers and District modeling staff, it was agreed that the LECRWSP 2005 input files would need to be modified to include IOP operations, as modeled with the 'Alt7r5' model run developed by the Corps for the Combined Structural and Operational Plan (CSOP) project. It was recognized that changes were likely not completed due to parallel track of CSOP 'Alt7r5' modeling and LECRWSP 2005 modeling.

2006LORS

This run was created from 2005LORS, but includes a canal capacity restriction in the EAA canals to mimic the maximum desired flows from Lake Okeechobee to STA 3/4. Annual total treatment capacity is 63,179 acre-feet (af).

2007LORS

This run was created from 2006LORS, but includes the operation of the temporary forward pumps for EAA water supply from Lake Okeechobee during dry times. Consistent with 2005LORS and 2006LORS, water supply deliveries to EAA are allowed during times of LEC demands for all days of the week. 2007LORS is a model representation of the future without project condition for the LORS alternative evaluation process.

2. Preliminary LORS Alternatives, General Overview

Eleven preliminary alternatives were formulated, refined, and evaluated by the LORS PDT during the time period of January through March of 2006. The features of these 11 alternatives are summarized in this section of the report. Additional graphics to illustrate the proposed regulation schedules and operational decision guidelines are available in a presentation under the 'alternative overview' link on the LORS webpage (<http://hpm.sfrestore.org/loweb/sfwmm/>). The last tier of these preliminary alternatives was included in the evaluation presented to the public in the first draft of the SEIS, and the original TSP (Alt1bS2-m) was selected from this set of alternatives.

a. General Assumptions

- 1) Average annual deliveries to STA-3/4 may not exceed treatment capacity:
 - Identified by District (February 2006) based on current nutrient levels in Lake Okeechobee;
 - 58,457 af (wet season); 4,722 af (dry season).
- 2) Supply Side Management (SSM) line lowered by 1.0 feet from current District line:
 - District recommendation as surrogate for 2006 SSM study, to be completed following selection of the LORS TSP;
 - Base condition (2007LORS) for alternative comparisons assumes current SSM line to remain in place.
- 3) All alternatives were developed from the 2007LORS alternative and include temporary forward pumps capable of pumping at the following capacities:
 - 600 cfs at S-351 (Hillsboro, North New River canals);
 - 400 cfs at S-352 (West Palm Beach Canal);
 - 400 cfs at S-354 (Miami Canal).
- 4) Backflow from St. Lucie canal to Lake Okeechobee is allowed at lake stages of 14.50 feet or 0.25 feet below the bottom of the lowest non-base flow regulatory zone, whichever is lower:
 - Operations developed to achieve similar performance to 2007LORS, while seeking to avoid frequent oscillation between regulatory releases and backflow releases at S-308;
 - Base condition (2007LORS) assumes backflow below 14.50 feet, which is always more than 0.25 feet below the lowest regulatory release zone (Zone D) under WSE;
 - Lowest non-base flow zone defined as follows: for Alt1a, Alt1aS1, Alt1aS2, Alt1b, Alt1bS1, Alt1bS2, Alt2b and Alt4, Zone D1; for Alt2a, cyan zone; for Alt3 Zone D

b. Alternative Overview

ALTERNATIVE 1A

This alternative was developed from the current WSE decision tree structure, with the following changes:

- The reshaping of the line representing the divide between Zone D and Zone E;

- Applying tributary hydrologic conditions that represent longer term wet or dry conditions that have persisted in the tributaries;
- Allow Base flow when Lake Okeechobee water levels are in Zone D0 or above, but no base flow releases when the stage falls below the bottom of Zone D (Zone D0).

ALTERNATIVE 1AS1

This alternative was developed from Alternative 1a. Alternative 1aS1 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D0 by 0.5 feet.

ALTERNATIVE 1AS2

This alternative was developed from Alternative 1a. Alternative 1aS2 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D0 by 1.0 feet.

ALTERNATIVE 1B

This alternative was developed from Alternative 1a, with the following changes:

- The bottom of regulatory zones A, B, and C are lowered, resulting in a more pro-active schedule to limit high water conditions in Lake Okeechobee;
- Reduced moderate to extreme high discharges to St. Lucie Estuary with modified discharge rates: Zone B maximum discharge at S-80 lowered from 3500 to 2800 cfs; and Zone C maximum discharge at S-80 lowered from 2500 to 1800 cfs.

ALTERNATIVE 1BS1

This alternative was developed from Alternative 1b. Alternative 1bS1 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D0 by 0.5 feet (similar approach as alternative 1aS1).

ALTERNATIVE 1BS2

This alternative was developed from Alternative 1b. Alternative 1bS2 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D0 by 1.0 feet (similar approach as alternative 1aS2).

ALTERNATIVE 2A

This alternative represents a new approach to the regulation schedule for Lake Okeechobee, developed from analysis of 1965-2005 data, with updated release guidelines:

- POR releases from S-77 and S-308 were added back to Lake Okeechobee historical elevation to develop simulated lake Okeechobee elevation with no releases made thru S-77 and S-308
- Probabilities for the rate of change in Lake Okeechobee with no releases to S-77 and S-308 were defined and summarized for 30, 60, and 90 day forecasting periods;
- Lake stage criteria for the upper 2 regulation guideline paths are defined based on a 50percent and 25 percent probability of the lake stage reaching 17.5 feet within 90 days, with the operational intent to recognize the COE-defined maximum elevation for Lake Okeechobee due to HHD as 17.5 ft;

- Tributary conditions evaluated using Palmer Drought Index and 2-week total Lake O. inflows, as used in alternatives 1a and 1b;
- Base flow zone is defined to target maintenance of lake stages above 12.56 navigation constraint stage and always above 2007LORS supply side management line;
- Regulatory releases from Lake Okeechobee to the Water Conservation Areas are discontinued for lake stage below 13.50 feet;
- Deviations from alternative 2a guidelines are included for active hurricane seasons

ALTERNATIVE 2B

This alternative represents a new approach to the regulation schedule for Lake Okeechobee. A desired lake stage curve, similar the Lake Okeechobee stage envelope PM, is the target:

- If the lake is below the stage curve, no regulatory releases;
- If the lake stage increases above the target stage, then successive regulatory release zones are encountered;
- The zones are roughly parallel to the target stage curve, and Zone A (maximum releases) is reached when the lake stage is roughly two feet above the target stage;
- Climate forecasting, as used in the current WSE regulation schedule, was also included (tributary hydrologic conditions are based on net rainfall and S-65E inflows to Lake Okeechobee)

ALTERNATIVE 2BS1

This alternative was developed from Alternative 2b. Alternative 2bS1 provides increased opportunity for base flow releases to the estuaries by lowering the bottom of Zone D1 (the lowest release zone) during the dry season.

ALTERNATIVE 3

This alternative is based on the Run 22AZE lake regulation schedule as previously evaluated under the WSE EIS (the previous lake regulation schedule study).

ALTERNATIVE 4

This alternative was developed from Alternative 1b, with the following modifications:

- Increase Zone B maximum Lake release to 6500/3500 and Zone C to 4500/2500;
- Lower regulation schedule during late hurricane season (change breakpoints for Zones A,B,C from 1 Oct to 1 Nov);
- Change decision tree for Zone C “base flow” to “up to Level 2”;
- Change decision tree for Zone D for THC (tributary hydrologic conditions) “normal”, SCO (seasonal climate outlook) “otherwise” to “up to Level 1”;
- Change decision tree for Zone D for THC “normal or wet”, MSCO (multi-season climate outlook) “otherwise” to “up to Level 1”;
- Allow base flow releases to Caloosahatchee Estuary (450 cfs at S-79) to the following lake level: 1-1: 12.56; 9-1: 12.56; 10-1: 13.0; 12-31: 12.56 (target maintenance of lake stages above 12.56 navigation constraint stage and always above 2007LORS supply side management line);
- Releases south to WCAs discontinued below Zone D0, as in Alt1b;

- Deviations from alternative 4 decision guidelines are included for active hurricane seasons.

ALT1BS2-A, ALT2A-A and ALT4-A

Based on guidance from the Corps' District Engineer, the following three alternatives were modified to allow "up to maximum discharge capacity to tidewater" (Zone A) when Lake Okeechobee stage exceeds 17.25 feet:

- Alternative 1bS2 modification is denoted as Alt1bS2-A
- Alternative 2a modification is denoted as Alt2a-A
- Alternative 4 modification is denoted as Alt4-A

Prior to this modification, the proposed regulation schedules for alternatives 1bS2, 2a, and 4 allowed "up to maximum discharge capacity to tidewater" (Zone A) when Lake Okeechobee stage exceeds 17.50 feet. The maximum discharge line at 17.50 is the operational guideline during the period from September 30 through March 31. The above-indicated modified alternatives lower this maximum discharge line by 0.25 feet (down to 17.25 feet elevation) during this same period from September 30 through March 31. No additional changes to the alternatives were incorporated with these modifications to the maximum discharge line.

ALT2A-B and ALT3-B

Based on guidance from the Corps' District Engineer, the following two alternatives were modified to require "up to maximum discharge capacity to tidewater" (Zone A) when Lake Okeechobee stage exceeds 17.25 feet, and include a zone for base flow releases of 450 cfs to the Caloosahatchee Estuary:

- Alternative 2a modification is denoted as Alt2a-B. The previous Alt2a model update with 17.25 for maximum discharges (Alt2a-A summarized above) will be the starting point, with one additional change: base flow zone will be modified to allow zero base flow to St. Lucie Estuary (450 base flow to Caloosahatchee Estuary only) as included in all other alternatives; discharges to WCAs will not be modified from the development of Alternative 2a, with discharges discontinued below lake elevation of 13.50 feet. Alternative 2a previously included base flow deliveries of 50 cfs to the St. Lucie Estuary from Lake Okeechobee.
- Alternative 3 modification is denoted as Alt3-B. The modifications to the previous formulation of Alternative 3 include: Zones A and B modified to allow maximum releases at 17.25 feet (previously 18.50), and a base flow zone added (same as Alternative 2a and alternative 4)

Note: As under RUN22AZE (WSE EIS) and previous Alternative 3 modeling, discharges to WCAs are discontinued below Zone E (13.50-15.50 feet elevation).

2007LORS-FWO

A new alternative was recommended by the Corps' District Engineer. The new alternative is a modification to the current WSE regulation schedule, with changes to require "up to maximum

discharge capacity to tidewater" (Zone A) when Lake Okeechobee stage exceeds 17.25 feet, and include a zone for base flow releases of 450 cfs to the Caloosahatchee Estuary. This run was created to represent the "future with operations modified" condition (fwo) that would be considered for implementation if one of the other LORS alternatives is not selected for implementation. Lors-fwo is a modification of the 2007LORS run; 2007LORS includes the current WSE regulation schedule, with maximum releases for Zone A defined for up to 18.50 feet elevation in Lake Okeechobee.

The modifications to the 2007LORS base, as required to create 2007LORS-fwo are summarized below:

- Zones A and B modified to allow maximum releases at 17.25 feet (previously 18.50)
- Base flow Zone added (same as Alternative 2a and Alternative 4; 12.56 is the navigation criteria for Lake Okeechobee)
- SSM line will be assumed lowered by 1.0 foot, as assumed for all other alternatives (see assumptions summary above)

ALT1BS2-M and ALT2A-M

Based on guidance from the Corps' District Engineer, Alternatives 1bS2-A and 2a-B were to be further modified. Alternative 1bS2-A was to be modified to eliminate all occurrences of Lake Okeechobee simulated stage above 17.25 feet, during the 36-year SFWMM period-of-record. Alternative 2a-B was to be modified to significantly reduce the frequency of extreme high discharge to the Caloosahatchee and St. Lucie estuaries, based on mean monthly flow volumes during the 36-year SFWMM period-of-record. The modified alternatives are denoted as Alternative 1bS2-m and Alternative 2a-m, respectively.

The modifications to Alternative 1bS2-A, as summarized below, were applied sequentially until the simulation results showed zero events above the stage of 17.25 feet for Lake Okeechobee:

- Regulation zones A, B, and C are lowered during the late hurricane season (September 30 stage breakpoints are changed to November 1, as under Alt4)
- Zone B breakpoints were lowered to be mid-way between the bottom of Zone A and the bottom of Zone C
- Lowered the bottom of Zone B by an additional 0.15 feet (in addition to #2) and lowered the bottom of Zone C by 0.10 feet, as the above modifications were unable to achieve zero exceedance of the 17.25 elevation

The modifications to Alternative 2a-B are summarized below:

- Increased releases in Zone Blue from 6,500/3,500 (Caloosahatchee/St. Lucie estuarine releases) to 7,500/5,000
- Changed Magenta regulatory releases to 800 cfs west / 400 cfs east measured at S-77/80 (Under Alternative 2a-B, the magenta zone was a zone allowing base flow to the Caloosahatchee estuary and regulatory releases south to the WCAs)
- Extended Magenta area to include below 13.5 ft to optimal line at 12.5 ft, consistent with the pre-defined operational guideline used to develop Alternative 2a
- Changed base flow line (bottom of orange zone) to match Alt1bS2 base flow zone

3. Final LORS Alternatives, General Overview

Following completion of the LORSS public meetings for the TSP and the receipt of public comments on the initial Draft SEIS, the decision was made to move forward with additional modeling to evaluate the potential to improve the performance of the TSP. This decision was the result of Corps internal meetings on September 22, 2006.

The new round of modeling included revised data sets and updated assumptions, as summarized below. The previous model output was no longer used for LORSS PDT evaluations and the old data was moved to the *Informational Runs* link on the LORSS modeling web page to avoid confusion.

Updated 2007LORS Base Condition

- The seasonal and multi-seasonal forecast files that were used up to July 2006 (as used for the previous LORSS modeling) were mistakenly computed with La Niña threshold of -0.04. The updated base condition simulation was corrected by utilizing re-computed seasonal and multi-seasonal forecast input data files based on the correct threshold. The LONINO control volume used in the computation was based on S-80, which is specified in the WSE Water Control Plan. The La Niña threshold error dates back to the 2005 LECRWSP simulation, selected as the best available representation of WSE operations in February 2006.
- The District recommended use of the pump option at the S-8 structure to provide additional water supply deliveries to the Big Cypress Seminole Tribe reservation. Previous base condition and alternative modeling assumed gravity deliveries. Based on discussions with District staff, the pump operation is likely to be used to ensure delivery of water supply, specifically under drought conditions.
- The SFWMM subroutine that computes the capacity of the EAA canals under the neutral case had some legacy code that made it rely on parameter values for other "Low Lake Okeechobee Stage Management" (as opposed to using the SSM operations). The source code was modified to correct this minor error.
- L-8 regulatory releases from Lake Okeechobee and L-8 local basin runoff will be routed to tide (through S-155A) and will not be routed through STA-1E. Based on discussions with District technical staff, STA-1E is not designed to treat L-8 local basin runoff or Lake Okeechobee discharges (associated with higher nutrient load). Previous LORSS base condition and alternative modeling assumed treatment of L-8 local basin runoff and Lake Okeechobee discharges by STA-1E, resulting in additional volumes of water being passed through STA-1E, WCA-1, WCA-2, and into WCA-3A.

Updated Alt1bS2-A17.25 and Alt1bS2-m (the initial TSP selected in June 2006)

- The updated model assumptions described above for the 2007LORS base condition were applied to all of the alternatives in the final review.
- Updated SSM methodology (now termed Lake Okeechobee Water Shortage Management Plan [LOWSM]) was included in the updated modeling. Earlier alternative simulations assumed a one foot lowering of the SSM line as a surrogate for this LOWSM plan that was under development by the District. The operational details of the LOWSM plan were provided to the LORSS PDT team by the District on October 10, 2006. The LOWSM methodology is not included in the SFWM source code used for the base condition, 2007LORS.
- Modified Low band breakpoints to assume Level 1 pulse releases within the bottom 1/3 of the band, Level 2 pulse releases within the middle 1/3 of the band, and Level 3 pulse releases within the upper 1/3 of the band. The previous modeling of Alternatives 1b, 1bS2, 1bS2-a17.25, 1bS2-m, and 4 included model inputs that resulted in a narrow band for Level 3 pulse releases within the Low band; the previous modeling did not modify the Low band breakpoints when the bottom of the intermediate band was lowered from alternative 1a to alternative 1b (and all derivatives from Alternative 1b). The operational decision tree for the low band does not specify the level of pulse release within the band (up to Level 3 pulse is allowed), and both modeling approaches do fall within the operational range of the low band.

Based on consideration of public and agency comments, three additional alternatives were developed in an effort to demonstrate potential improvements to the initial TSP. In an effort to allow the storage of additional water within Lake Okeechobee (compared to the initial TSP Alt1bS2-m), while simultaneously recognizing the need to provide for public health and safety under high lake levels, the starting point for these additional alternatives was the updated version of Alt1bS2-a17.25.

Alternative T1

Alternative T1 (TSP modification 1) was proposed by the Corps Water Management Section. The following changes were made to Alternative 1bS2-A17.25:

- Changed the late season break points from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address the potential of late season hurricanes.
- Changed the Level 3 pulse release measured at S-77 from an average daily flow of 3,000 cfs to 2800 cfs.
- Included a base flow of 350 cfs to the St Lucie, measured at S-80, in low and intermediate bands.

- Changed the base flow on the Caloosahatchee from up to 450 cfs at S-79, to up to 650 cfs measured at S-77, in the low and intermediate bands.
- No changes to base flow of 450 cfs measured at S-79 in the base flow band.
- Raised the bottom of the base flow band by 0.25 feet.
- Change the High and Intermediate band flow of up to 2,800 cfs measured at S-80 back to the WSE level of up to 3,500 cfs.

Alternative T2

Alternative T2 (TSP modification 2) was proposed by the District. The following changes were made to Alternative 1bS2-A17.25:

- Zone D0 raised to 12.6 ft (Zone D0 should be higher than navigation minimum of 12.56').
- All Caloosahatchee pulse releases are measured at S-79 instead of S-77 (in all lake bands when pulse releases are called for, to reduce high flow exceedences caused by lake release plus runoff).
- Bottom of Zone D1 lowered by 0.5 ft (to encourage more pulse releases which help reduce steady high discharges).
- Added a small base flow of 200 cfs (*i.e.*, low volume regulatory discharge) at S-80 (whenever base flow releases are called for in decision tree).

Alternative T3

Alternative T3 (TSP modification 3) was developed through the collaborative efforts of the Corps and District, following LORSS PDT review of the updated alternatives and the new T1 and T2 alternatives. (Note that the Corps has renamed the TSP in the revised draft SEIS to Alternative E. This FWCA report will continue to refer to the TSP as Alternative T3.) Alternative T3 was developed from Alternative T2, with the following changes:

- Changed the late season break points from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address the potential of late season hurricanes (consistent with alternative T1).
- Inclusion of an Oct. 1 breakpoint at 13.0 ft for the bottom of the base flow Zone D0 (consistent with original LORS Alternatives 2a and 4 to provide some protection to low lake levels at the end of the wet season).

- Increased Caloosahatchee Level 1 pulse from average daily rate of 1,600 cfs to 2,000 cfs (allows for increased releases below 2,800 cfs to reduce higher lake levels and the associated higher releases).
- Increased Caloosahatchee Level 2 pulse from average daily rate of 2,300 cfs to 2,500 cfs (allows for increased releases below 2,800 cfs to reduce higher lake levels and the associated higher releases).
- Caloosahatchee Level 3 pulse remain unchanged, at average daily rate of 3,000 cfs.
- Reduce maximum Caloosahatchee discharges from 4,500 cfs to 4,000 cfs when the Lake Okeechobee stage is within the intermediate (normal to wet) or low (very wet) bands.

VIII. EVALUATION OF THE ALTERNATIVES

Project alternatives were analyzed in a step-wise manner. Each alternative was evaluated against the others, and against the 2007LORS No Action alternative in order to identify which ones best approached the multiple goals of the project. The outcome of each step in the analysis resulted in the modification of several of the alternatives to improve their performance for continued evaluation.

Each PDT member agency conducted their own evaluations, and these agency evaluations were shared with the entire PDT and discussed during weekly meetings. The Service focused its evaluations on the ecological performance measures, primarily those related to lake ecology and the estuaries, but also paid special attention to evaluations of the Everglades indicator regions that were led by the District.

After the Corps reviewed the public comments regarding the TSP outlined in the initial Draft SEIS, the decision was made to reformulate the alternatives and further develop the TSP so as to improve its performance in several areas, particularly its effects on the Caloosahatchee River and estuary. At the same time, the Corps modelers took the opportunity to address several deficiencies in the existing model by modifying assumptions and updating some model parameters to increase its accuracy and reliability. Although most of these model changes were minor and unrelated, the net effect of the changes was enough to change the performance output for all modeled alternatives. Consequently, the results of the modeling that was conducted during the final alternative evaluation cannot be compared to the earlier modeling results.

The tables that have been included with this report document the environmental performance measure model output for only the final set of alternatives. The same performance measures were used by the Service to evaluate all alternatives throughout the history of this project, but only those modeling results for the last tier of alternatives are included in the evaluation tables, due to the incompatibility of comparing them with the older model results. Tables of the old series of alternative evaluations are included in Appendix B to illustrate the respective performances of all the project alternatives from the beginning of plan formulation.

Caloosahatchee Estuary

Performance measures for the Caloosahatchee estuary are tied to freshwater flow rates measured at S-79, including lake releases. Flow rate is used as a surrogate measure for estimating the salinity within the estuary. Please refer to Table 1 for a side-by-side comparison of the final tier of alternatives and their respective performance measure output. The model output for the initial alternative evaluations can be found in Table B-1 of Appendix B.

Initial Alternatives

From the beginning of the project evaluation, the Service supported variations of the *Alt1* line of alternatives. During the first tier of evaluations, Alt1 provided the best performance for the Caloosahatchee estuary, particularly in reducing the number of high flow events (>2,800 cfs). When this alternative was modified and split into derivative alternatives, we supported, in sequence, Alt1a, Alt1aS2, and finally Alt1bS2-A, all for the reasons of reducing the number and duration of high flows to the estuaries. Due to the inclusion of base flow requirements, these alternatives were also successful at reducing the number of low flow events to the estuaries. When Alt1bS2-A was modified to Alt1bS2-m (which was picked as the original TSP), its performance for high flows was degraded considerably.

The series of *Alt2* alternatives never performed well for the Caloosahatchee estuary. This line of alternatives was designed from the beginning to reduce high stages within Lake Okeechobee to the maximum extent possible, which resulted in the consequent negative impacts on the downstream estuaries. In all derivations of this series of alternatives, the high flows to the Caloosahatchee estuary were increased in both number and duration of the events. The Service consistently did not support any version of the Alternative 2 series. However, during the last revision of the final two alternatives prior to the release of the initial draft of the SEIS in August 2006, Alt2a was changed to Alt2a-m and its performance for reducing high flows was drastically improved, and substantially exceeded the performance of Alt1bS2-m (which had been chosen as the initial TSP).

Alternative 3 was initially included in the project evaluation as a holdover from the last time the regulation schedule was revised (it was originally known as Run22 AZE). It was not expected to perform well during the current schedule revision, because the water management system and its operations have changed considerably since this alternative was first developed. Indeed, the initial incarnation of Alt3 had mixed performance results for the Caloosahatchee. While it reduced the total number of high flow events to the estuary, those that remained tended to have much larger flows and for substantially longer durations. Additionally, the number of times that the minimum low flow targets were not reached during the dry season increased slightly over 2007LORS, due to the lack of base flow releases to the estuaries in this alternative. However, when this alternative was modified to include base flow and other minor improvements (then called Alt3-B), its performance in the Caloosahatchee was improved to a significant degree, and it ended up being the best alternative for this estuary. Unfortunately, its poor performance in other parts of the system precluded it from being selected as the TSP.

The two variations of Alt4 had mixed results for the Caloosahatchee. While they performed well in most categories, such as reducing the total number of high flows (>2,800 cfs), they also

increased the number and duration of the extreme high flow events (>4,500 cfs). Alt4-B was not selected as the initial TSP due to poor performance in the lake.

Final Alternatives

Alternatives Alt1bS2-A and Alt1bS2-m (the initial TSP) were both re-modeled with the improvements to the model. Additionally, Alt1bS2-A was also revised sequentially to develop Alternatives T1, T2 and T3 (the new TSP). Generally speaking, the revised Alt1bS2-A and Alt1bS2-m performed better than their initial versions, with the important exception of the long duration extreme high flows to the Caloosahatchee estuary. Alternatives T1 through T3 all offered improvement over the initial TSP, with T2 and T3 performing the best. The differences between T2 and T3 were minor; however, T3 has fewer long duration high flows (>45,00 cfs for >5 weeks) than T2.

Compared to the 2007LORS base run, Alt-T3 would reduce the total number of high flow events (>2,800 cfs) from 74 to 64 over the period of record. The number of extreme high flow events (>4,500 cfs) would remain unchanged at 29, but the duration of these events would be increased, with the number of times the moving weekly average flow exceeding 4,500 cfs for longer than 5 weeks increasing from 28 to 65. The end result of this analysis is that the proposed TSP would likely have a net positive effect on the upper estuary, but with the cost of potentially worsening conditions in the lower estuary and San Carlos Bay.

St. Lucie Estuary

As with the Caloosahatchee estuary, freshwater flow from Lake Okeechobee was used to measure the performance of the alternatives with respect to their effects on the salinity within the St. Lucie estuary. Please refer to Table 2 for a listing of each of the final tier of alternatives with its respective performance measure output. The model output for the initial alternative evaluations can be found in Table B-2 of Appendix B.

Initial Alternatives

The performance of the initial alternatives for the St. Lucie River and estuary is very similar to their performance in the Caloosahatchee, although with far less dramatic differences. As with the Caloosahatchee, the variations of Alt1 tended to be some of the better performing alternatives, and the variations of Alt2 tended to perform worse. Again, Alt3-B was an exceptional performer for all performance measures except for low flow events, but as already mentioned, this alternative was eliminated because of poor performance in the lake. Unexpectedly, Alt4 and Alt4-B performed consistently well in this estuary, but again, poor lake performance precluded them from selection.

Final Alternatives

The only alternative in the final tier that did exceptionally well in the St. Lucie estuary was Alt-T1. However, since T1 was considered unacceptable from the perspective of the Caloosahatchee, Alt-T2 was further refined to result in Alt-T3, which greatly improves the performance over T2 for the St. Lucie. Alt-T3 improves low flow considerably, and slightly reduces the number of high flow events (>2,000 cfs) from the base condition, though not to the extent that T1 did. For some reason, T3 increases the frequency of average bi-weekly flow

events (>2,000 cfs) from the local drainage basin, though the number of these events coming from lake discharges would be reduced relative the No Action alternative.

Lake Okeechobee

As can be expected, those alternatives that performed best for the estuaries did not perform as well for Lake Okeechobee. Please refer to Table 3 for a side-by-side comparison of the final tier of alternatives and their respective performance measure output. (Table B-3 in Appendix B shows this same information for the initial set of alternatives.) It was generally thought over the past 15 years or more that a lower average annual lake stage would be beneficial to the lake's littoral marshes. In reviewing our files, we found that the general consensus was that the lake elevation should be an average of 2 feet lower than the current average annual elevation; however, the results of the modeling study for this project show that an average 2 ft drop may, in fact, be excessive, and possibly detrimental to lake ecology. The initial TSP (Alt1bS2-m) lowered the average lake stage about 1.0 to 1.5 ft lower than 2007LORS, depending on the time of year (this is approximately 2.0 to 2.5 ft lower than actual levels). While this drop in elevation is desirable from a flood control perspective, it may end up causing harm to the lake's littoral zone due to drying out too frequently, and for longer periods of time, in drought years.

The problem inherent with moderating the extreme highs and lows of the average lake elevation is that it is difficult to devise operational strategies that simply shave off the high and low peaks from the annual stage hydrograph. As the modeling of the numerous alternatives for this project demonstrates, the annual hydrograph generally maintains a consistent shape between alternatives, with the entire hydrograph rising or dropping dependent upon the particulars of a given alternative. Consequently, those alternatives that are best at reducing the high peaks in the average lake elevation also tend to increase the severity of the low troughs, causing the lake elevation to fall lower for longer periods of time.

Initial Alternatives

Those alternatives derived from the original Alt2 consistently lowered the lake to the greatest extent (sometimes over 1.5 ft lower than 2007LORS or 2.5 ft lower than current levels). For certain groups of performance measures, for example those associated with flood control, the Alt2 variants produced the best performance, but at a cost to the ecological performance measures. The periods of time when the lake's littoral zone dried out tend to be more extreme and last longer with the Alt2 series of alternatives.

The Alt1 derivatives also lowered the lake stage, showing a marked improvement over the baseline alternative (2007LORS), but they did not lower the lake to the same extent as the Alt2 series of alternatives. During the early evaluations of the project alternatives, the Alt1b variations consistently scored highest in overall performance (including the estuaries and other downstream systems), and demonstrated the best overall balance of project objectives. But when the goal of the project changed to maximize flood control at the expense of all other competing project objectives, only the Alt2-series of alternatives remained viable.

The last alternative modifications prior to the release of the initial Draft SEIS (which changed Alt1bS2-A to Alt1bS2-m, and Alt2a-B to Alt2a-m), reversed the performance of the two

originating alternatives. Alt2a-B, which was originally best for the lake and worst for the estuaries reversed itself, and became better for the estuaries. Similarly, Alt1bS2-A was originally better for the estuaries than Alt2a but not as good for the lake (it exceeded the 17.25 ft high lake stage constraint for 12 days out of the 36 year period of record), and was changed to improve its performance in the lake (by removing any days in the simulation exceeding the 17.25 ft constraint), but became damaging to the Caloosahatchee estuary. This was the alternative that was chosen as the initial TSP, and consequently generated a large amount of negative public feedback.

Final Alternatives

The final tier of alternatives was based on Alt1bS2-A, and therefore did not negatively affect the estuaries to the same extent as the initial TSP (Alt1bS2-m). Their effects on the lake, however, were less straightforward. It appears that the new TSP, Alt-T3, lowers the lake more often than the initial TSP, but for shorter periods of time. For example, the new TSP, Alt-T3, drops the lake stage below 13.5 ft 31 times over the period of record, with an average duration of 236 days for each event, but the initial TSP, Alt1bS2-m, would have dropped the lake below this stage 27 times with an average duration of 255 days per event.

Greater Everglades

The Service initially evaluated the project alternatives relative to several downstream performance measures, including the effects to snail kites and the Cape Sable seaside sparrow within the WCAs and Everglades National Park. Our review of the model output showed that although there were some differences in the performance of the alternatives, these differences showed no discernable pattern, and were minor. This is likely because the operational decisions in the SFWMM operate the WCAs on the line of their respective regulation schedules. We therefore chose to concentrate our review on the effects of the project on the estuaries and lake ecology.

The District conducted their own review of the project effects within the Everglades, and we referred to their analyses during the PDT discussions of alternative performance, paying particular attention to the performance measure for snail kite habitat. Their evaluation reinforced our opinion that project effects in the downstream WCAs were insignificant. Even given the minor differences between the alternatives, all of them performed slightly better than the baseline for snail kite habitat.

IX. POTENTIAL ADVERSE AND BENEFICIAL EFFECTS OF THE TENTATIVELY SELECTED PLAN

A. Effects on the Caloosahatchee Estuary

The effects that the final TSP (Alt-T3) has on the Caloosahatchee estuary are complex and in some ways contradictory. There are several data output parameters from the SFWMM that illustrate the manner in which this alternative affects freshwater flows to this system. First, Alt-T3 would decrease the amount of water (on an annual average) sent to the estuary due to regulatory releases by approximately 3,730 af (about 1 percent of the 2007LORS flow). The

amount of water sent to the Caloosahatchee in the form of base flow releases during the dry season and periods of drought will increase by 40,370 af, for a net total increase in annual average flows of 36,640 af. This represents approximately a 10 percent increase in flows from the 2007LORS to the TSP. Because all of the additional increased flow would be intended to reduce the number of low flow events, this would be considered a beneficial effect to the estuary, except perhaps for water quality issues.

Another measure of high flow to the estuary is the moving average weekly flow of > 4,500 cfs measured at S-79. The TSP reduces the number of these events compared to the 2007LORS base condition by 17 weeks (132 weeks in 2007LORS to 115 weeks in Alt-T3). However, in examining the distribution of these moving average weekly flows >4,500 cfs, we noted that the flows that remain are more tightly clustered in the TSP, so that each event with a flow >4,500 cfs lasts longer than the corresponding events in the 2007LORS base run. The number of long duration, extreme high flow weeks (> 4,500 cfs for more than 5 weeks) would more than double from 28 to 65 over the 36 year period of record. Because the long duration flows > 4,500 cfs are the most damaging to the lower estuary from Shell Point to San Carlos Bay and the J.N. “Ding” Darling NWR, the Service is concerned about the increase in the duration of these flows. The TSP is essentially redistributing the flows to the estuary in a manner that decreases the number of times that damaging flows reach the estuary, but increasing the duration and severity of those flow events that remain.

Overall, the total amount of water released during regulatory discharges would be reduced, as would the number of times these large discharges would need to be made, but when these high flow events increase substantially in duration, impacts to the lower estuary can be severe. Oysters and seagrass beds are important estuarine resources in this area that would be negatively impacted by these long duration extreme high flows. These sessile species cannot move to areas of preferred salinity ranges although they can tolerate low salinity levels for short durations. These species become more susceptible to disease, predation, and even death as the duration of extreme high flow events increase. The TSP therefore has a greater potential than the base condition to reduce the density and cover of seagrass beds in the lower estuary and/or contribute to shifts in their community composition. Additionally, the TSP has a greater potential than the base condition to reduce the abundance and productivity of oysters in the lower estuary and potentially flush oyster spat downstream to areas less suitable for establishment and long-term survival.

A positive benefit of the TSP is that it is effective at reducing the number of low flow events. As previously discussed, a minimum amount of freshwater flow from the lake is necessary during the dry season to compensate for the lack of fresh water flowing into the estuary from the local drainage basin. The total number of low flow events over the 36-year period of record would be reduced by 34 percent under the TSP. The TSP would, therefore, benefit the estuary by providing water to the estuary when there is little to no basin flow due to limited rainfall and increased water supply demands, with the exception of potential increases in nutrient loading. The decrease of low flow events would likely reduce the frequency of MFL violations in the estuary, and help to maintain the long-term viability of the *Vallisneria* beds in the upper estuary.

B. Effects on the St. Lucie Estuary

The effects of the final TSP (Alt-T3) on the St. Lucie estuary are less dramatic than on the Caloosahatchee estuary. The total number of monthly high flow events (>2,000 cfs) is reduced only slightly, from 74 to 73 over the period of record. Extreme high flow events (>3,000 cfs) remain unchanged from the base run. The number of times that large regulatory releases are made from the lake with moving bi-weekly average flows >2,000 cfs would be reduced from 52 to 49, but this drop would be offset by an increase in the bi-weekly high flow events from the local drainage basin, from 72 to 79 events.

The total amount of water sent to the St. Lucie estuary on an average annual basis would increase by 22,820 af, most of which would be in the form of base flow releases during the dry season. Although the St. Lucie estuary does not require a minimum amount of base flow from Lake Okeechobee in order to maintain proper estuarine salinity levels during the dry season, it would still be beneficial to reduce these low flow events as much as possible to extend the benefits of dry season base flow into the Indian River Lagoon. The TSP reduces the total number of low flow events substantially, from 127 to 103 events over the period of record compared to the 2007LORS.

C. Effects on the Lake Okeechobee Littoral Zone

Any alternative that does not substantially “flatten” the annual hydrograph can be only marginally successful at restoring the lake’s littoral zone close to the more favorable vegetation patterns in the Pesnell and Brown (1977) littoral zone survey. However, this cannot be achieved with the current infrastructure surrounding the lake; much more dynamic storage will need to be connected to the lake. Lowering the annual average lake elevation typically results in lowering the probability of ecological stress due to high lake stages, yet increases the probability of stress because of low lake stages. Of particular concern is the suitability of the littoral habitat for the apple snail.

The apple snail is not highly mobile. Unlike some other aquatic animal species, apple snails will not move extensively to follow the optimal water conditions that will vary with season and year (Darby et al. 2002). When a portion of the littoral zone inhabited by apple snails dries out because of lowering lake stage, the snails will imbed in the surface layer of detritus and await the return of the water. After a period of time, the snails will die if the area remains dry. Therefore, when discussing the drying of the littoral zone, it is important to keep in mind not only how low the water gets, but even more importantly, for how long the water level stays low.

High water levels are also destructive to snail habitat. Once the water depth in a particular area exceeds approximately 40 cm, the area is considered to be too deep to allow snails to breed. Higher lake stages also allow wind storms to tear out emergent vegetation, particularly along the outer edge of the littoral zone. Because the snails must breath air, they need stems to climb to survive; they also need portions of the stems to remain above water level for their eggs to hatch. When the extremely high lake stages are regularly interspersed with extremely low lake stages, apple snails are not given an opportunity to recover their numbers. Because of this, those

alternatives that show large intra-annual variation in water elevations, in particular during the spring snail breeding season, are poorly suited to providing and maintaining good apple snail habitat. The TSP is neither better nor worse than the other alternatives in providing a more even water elevation during the spring; however, it does increase the extent of the littoral zone that dries out during each low water event, and also increases the amount of time that the littoral zone remains dry, thereby increasing the likelihood of mortality of apple snails. However, it also decreases the maximum water depth and number of times that the littoral zone becomes too deep to support breeding snails.

We conclude the performance of the TSP would be better than the 2007LORS run for wading birds. Because fish, amphibians and large crustaceans tend to be the most common food source for wading birds, shallow water and gradually receding water levels are important for concentrating their food supply. Unlike the apple snail, these prey items can move with lowering water levels to varying degrees, so actual water elevation is not as important to wading birds as is the rate of elevation change during the spring. This is called the spring recession period, and the TSP performs slightly better than the 2007LORS alternative in providing gradual recessions during the spring months. In addition to the greater ability of fish to persist through periods of lower water levels, they also are more rapid in repopulating the littoral zone once it has re-flooded. This is the basis for our finding that lower water levels are generally beneficial for wading birds, including the endangered wood stork, while at the same time would, on balance, have some adverse effects on the endangered snail kite.

D. Effects to the A.R.M. Loxahatchee NWR

The existing performance measures for this project are too coarse to adequately evaluate potential effects to the Refuge. The primary concern is that the annual average water elevation within Lake Okeechobee will drop to such a degree as to prohibit the pre-emptive replacement water releases to the Refuge. These releases can only be made if the water elevation within the lake is no more than 1.0 ft lower than the water elevation within the Refuge. Although it is difficult to compare the water elevations from a model run to elevations from the historical record, it appears as though the TSP will lower the average annual water elevation in Lake Okeechobee by about 1 to 2 ft, depending on the time of year. When comparing the stage hydrographs for Lake Okeechobee and the Refuge, it appears that over the 36-year period of record, there would have been only a single instance of replacement water not being able to be sent from the lake to the Refuge in both the TSP and the 2007LORS run, so there would apparently be no change on the Refuge from the TSP.

Review of the stage duration curves for indicator regions within the Refuge shows that the TSP would have little effect on Refuge water elevations, although there is a slight increase in stage duration at the dry end of the duration curve, which would be a benefit to the ecosystems within the Refuge. We recommend more detailed and in-depth analyses of this issue be included in the next revision to the regulation schedule to be implemented in 2010.

The Service is uncertain why the current modeling does not show obvious impacts to the Refuge, when the empirical evidence from past droughts would suggest that the impacts on the Refuge

may be greater than the modeling predicts. There are a number of possible explanations for this apparent discrepancy. One explanation is that, in fact, this change in regulation schedule would not adversely impact the Refuge. Another might be that the SFWMM lacks adequate spatial resolution to detect impacts on the Refuge. A third possibility is that the model insensitivity is a result of the operational decisions within the SFWMM to operate the Refuge “on the line” of the WCA-1 regulation schedule. A fourth possibility is that the consumptive use of water from the Refuge is not adequately modeled in the SFWMM. Finally, the SFWMM does not account for the increased risk to the Refuge due to more frequent and longer deviations from the Refuge’s water regulation schedule to meet water supply demands.

E. Lake Okeechobee Minimum Flows and Levels (MFL)

The MFL documentation for Lake Okeechobee states that the harmful lake stage of <11 ft for >80 days should not occur more than once every 6 years. The final TSP (Alt-T3) slightly increases the number of times the lake drops below 11 ft for more than 80 days compared to the 2007LORS base condition (an increase from 5 to 6 times). The lake stage hydrograph for the period of record indicates that the low lake stages from the TSP tend to be grouped into three periods when two low water events occur within 6 years of each other, resulting in three violations of the MFL regulations. In contrast, the 2007LORS base run shows two violations of the MFL.

Because the TSP would increase the frequency and duration of extreme low water events to the degree that there may be additional violations of the MFL, this may necessitate the implementation of a recovery strategy (as defined in the MFL legislation) for mitigating impacts on the lake. In recent public forums, the Service has heard discussion of possibly restocking apple snails in the littoral zone to mitigate these adverse effects. While the Service supports the testing of this method of species conservation through a pilot study, it is unclear if this will prove to be a viable strategy to compensate for the adverse effects the TSP may have on snail kites. A pilot study could determine if restocking snails into the littoral zone after drought has a localized effect in speeding up recovery of apple snail populations. However, to be part of an effective recovery strategy for the snail kite, it would have to be practical on a larger scale. We also must point out that a large standing stock of apple snails would have to be maintained continuously at the ready in case a drought occurs, but unlike several recreationally important fish, we are unaware that this stock is already commercially available.

F. Operational Guidance

Appendix A of the Draft SEIS describes overall operational guidance for the Lake Okeechobee regulation schedule. This guidance emphasizes the need for Additional Operational Flexibility (previously known as Non-Typical Operations) for water managers to be able to respond to unanticipated events outside of the normal predictive capability of the TSP modeling. The result of such a wide degree of operational flexibility is that the hydrologic models used in plan formulation may no longer reflect the operations of the prescribed plan. The Corps states in the Draft SEIS that this additional operational flexibility would be rarely invoked, but the circumstances they describe that would warrant implementation of the increased operational

flexibility are broad. Based on the number of times that the Corps has requested deviations from the existing schedule in the past several years, the Service is concerned that application of this additional operational flexibility will be more common in practice than they anticipate.

The operational guidance also proposes the concept of “make-up” discharges from the lake. This basically addresses the instances when water managers want to release water from the lake to downstream systems, but are precluded from doing so due to restrictions in the regulation schedule that limit the amount of water that can be sent to specific areas at specific times. This would essentially create a “backlog” of releases that would be carried out in large quantities at a later date, which may have unanticipated negative effects on the downstream systems to which this water is released.

An integral component of the proposed operational guidance is the use of District (and other state-owned) lands as temporary water storage facilities for times when the lake needs to be lowered, but releasing water to the estuaries would be undesirable. This is a concept that has only recently been added to the operational guidance, and has not been fully evaluated for its environmental consequences to the receiving lands. Nor have the practical aspects of implementing this strategy been fully investigated, and more work needs to be done to determine the effectiveness and practicality of this proposed measure.

G. Summary of Consultation under the Endangered Species Act

On June 30, 2006, the Service received a letter from the Corps requesting initiation of formal consultation under the provisions of section 7 of the ESA. The consultation concerns the possible effects of the proposed revision to the WSE regulation schedule for Lake Okeechobee on the following federally listed species:

COMMON NAME	SCIENTIFIC NAME	STATUS
Snail kite	<i>Rostrhamus sociabilis plumbeus</i>	E (CH)
Wood stork	<i>Mycteria americana</i>	E
West Indian manatee	<i>Trichechus manatus</i>	E (CH)
Bald eagle	<i>Haliaeetus leucocephalus</i>	T
Cape Sable seaside sparrow	<i>Ammodramus (=Ammospiza) maritimus mirabilis</i>	E (CH)
Eastern indigo snake	<i>Drymarchon corais couperi</i>	T
Okeechobee gourd	<i>Cucurbita okeechobeensis</i> ssp. <i>okeechobeensis</i>	E

E=Endangered; T=Threatened; CH= designated Critical Habitat

The Corps provided a Biological Assessment to the Service that stated the proposed TSP would have “no effect” on the eastern indigo snake, bald eagle, Cape Sable seaside sparrow and West Indian manatee. The Corps also provided a determination of “may affect” with beneficial effects for the wood stork, Okeechobee gourd and Everglade snail kite. The Service has reviewed the analysis of the hydrologic changes predicted for the regulation schedule and based on our knowledge of the project and our preliminary analysis of the modeling results, we concurred with the Corps’ determination that the proposed project will have no effect on the bald eagle,

eastern indigo snake and the Cape Sable seaside sparrow, but do not concur with this determination for the manatee. We concurred that the project may affect, but is not likely to adversely affect the wood stork, and Okeechobee gourd, and have included the manatee in this category as well. The Service does not concur with the Corps' determination that the project may affect, but is not likely to adversely affect, the Everglade snail kite or its designated critical habitat. Therefore, we will formally consult on this species in a Biological Opinion. Specifically, the Service is concerned about the effects of the TSP on the apple snail population within the lake's littoral zone, and the resulting effects on the kite. Our complete analysis of the effects of this project on the snail kite and its critical habitat will be included in our forthcoming Biological Opinion.

X. RECOMMENDATIONS/CONSERVATION MEASURES

Lake Okeechobee has been called the heart of the central and south Florida water management system. As such, the schedule that regulates when, where, and how much water is released from the lake to downstream systems is a critical component in maintaining a proper water balance throughout south Florida. The Service is providing recommendations on this project in order to make the project more environmentally compatible and to further enhance the diversity and abundance of fish and wildlife resources in the project area. In view of the broad reach in time and geographic area of the potential effects of this project, our recommendations are mid- to long-term, including the next phase in the development of the regulation schedule that will incorporate the Band 1 set of CERP components.

1. The federally endangered Everglade snail kite has suffered a decline throughout south Florida over the past decade, and its nesting effort and success in Lake Okeechobee has been low for about 15 years. This is due, in part, to the drop in numbers of apple snails within the lake's littoral zone. Our understanding of the current status, distribution and population trends of the apple snail in the lake is incomplete. To provide this critical information, we recommend an annual monitoring program be implemented, in selected sample locations throughout the littoral zone of the lake.
2. The existing CERP performance measures for evaluating project effects on snail kites are difficult to apply to Lake Okeechobee. The Service is committed to assist in developing reliable and sufficiently sensitive performance measures to specifically analyze the effects on snail kite feeding and nesting and in the lake.
3. The Regional Simulation Model (RSM) may be more effective in analyzing effects of the regulation schedule than the SFWMM, and if available, should be used in place of the SFWMM during the next revision of the regulation schedule. The RSM would provide better resolution of key areas of ecological concern (including A.R.M. Loxahatchee NWR; see below). Although some initial screening of alternatives could be performed with the SFWMM, the final plan should be selected from the final suite of alternatives with the more powerful RSM. This will require substantial effort to develop, test, and calibrate the RSM model, which is currently not in routine use, particularly with regard to

system-wide performance measures that are necessary to evaluate water regulation of Lake Okeechobee.

4. The Service finds that current indicator regions and performance measures do not adequately assess the effect of the Lake Okeechobee regulation schedule on the A.R.M. Loxahatchee NWR (WCA-1). The regulation schedule for Lake Okeechobee has a direct influence on the ability to provide replacement flows to the Refuge in response to urban water supply demands. We recommend that modelers review how accurately simulations capture the effects of water supply withdrawals from WCA-1 during periods of drought and the degree of impact such withdrawals will have on the need to seek deviations from the 14 ft floor of the regulation schedule for WCA-1. The Service believes that the necessary revisions to indicator regions in the Refuge and improved simulation of water supply demands can be achieved in the transition from the SFWMM to the RSM, and these need to be completed prior to selection of alternatives in the next phase of planning for the regulation of Lake Okeechobee.
5. To reduce the dependency of the Lake Worth Drainage District on water drawn from A.R.M. Loxahatchee NWR to meet dry season demands, we recommend that water be routed from the C-51 Canal around the Refuge to the E-1 Canal. We believe the relatively modest structural modifications needed to achieve this goal can be implemented well before construction is completed on the CERP Band 1 projects. Incorporating this capability into the simulations in the next phase of planning for regulation of Lake Okeechobee would be advantageous in minimizing impacts of low water on the Refuge.
6. In the next phase of the regulation schedule revision, water supply deliveries from Lake Okeechobee to the EAA during drought should not exceed those in the current version of the LOWSM. Any additional removal of water from the lake through the permanent forward pumps than is currently predicted to occur through the temporary forward pumps would likely have severe impacts on the ecology of the lake, including an even greater likelihood of MFL violations. If water demands are projected to increase from the Lake Okeechobee Service Area, these should be met through efficient operation of the planned EAA Reservoir, rather than through additional discharges through the permanent forward pumps.
7. Potential impacts to the lower Caloosahatchee estuary and the J.N. “Ding” Darling NWR from high freshwater flows could be better assessed with more intensive monitoring programs. We recommend that salinity, water quality (e.g., nutrient levels and other parameters) and aquatic vegetation monitoring be established and/or expanded to locations not currently monitored.
8. The Service recommends that the next schedule revision prioritize reducing both the number and duration of flows greater than 4,500 cfs at S-79 resulting from regulatory releases.

9. Water quality concerns in the Caloosahatchee and St. Lucie estuaries were not adequately evaluated in the current regulation schedule study. The CERP program has several water quality performance measures designed specifically to analyze nutrient issues in the northern estuaries and we recommend that these performance measures should be used for the next schedule revision in 2010.
10. Base flow (or the lack thereof) to the Caloosahatchee estuary is a component of the MFL for this estuary. The Caloosahatchee is burdened with an unfair portion of the “shared adversity” when discharges intended to prevent violations of the MFL are terminated at a higher lake stage than the initial level of cutbacks to water consumers in the EAA in accordance with the LOWSM. The Service recommends that future revisions to the schedule include delivery of a base flow to the estuary that will not be curtailed until the initial phases of water supply cutbacks are in effect.
11. The Operational Guidelines for the LORS were revised with very little time for input from the PDT. During the next regulation schedule revision, discussions regarding the guideline revisions should occur concurrently with the regulation schedule revision process, so that PDT member concerns can be addressed adequately and completely.
12. Appendix A of the Draft SEIS describes overall operational guidance for the Lake Okeechobee regulation schedule. While a certain level of operational flexibility is desirable, we find that the proposed operational guidance is too vague and provides too much uncertainty for stakeholders. The next phase of this study in the years 2008 to 2010 should attempt to ensure that the hydrologic models used in plan formulation follow as closely as possible the proposed operations of the prescribed plan. Aside from building trust among the stakeholders, we believe this disciplined approach has pragmatic advantages. First, closely following the operations described in the model should allow feedback into adaptive management of the lake which will be increasingly important as features of the CERP come on line. Conversely, too much operational flexibility will not allow confidence in the ability of the hydrological models to reflect what has happened or to predict the effects of proposed changes in and around the lake. Second, other critical components of the C&SF system intimately linked to the central role of Lake Okeechobee in water management for south Florida must have consistent modeling assumptions about operation of the lake to make them work effectively together. Such consistency would be invaluable for the next revision of the Systems Operating Manual, which is a separate planning effort for managing water in south Florida.
13. The Service recognizes that the Corps and the District have distinct authorities; within their partnership, the Corps takes the lead on decisions related to operation of the C&SF system for flood control and the District has the primary authority with respect to water allocations. However, these two aspects are inextricably linked in terms of the overall water budget for the lake. Regardless of any legal decisions about what may be termed a Federal action or a State action, accurate modeling of the water budget requires both agencies to reach agreement throughout the planning process on management decisions across the full range of water conditions. In the current plan formulation effort, the Corps

and the SFWMD had difficulty in coordinating these decisions, particularly with respect to acceptable risks to the integrity of Herbert Hoover Dike, the potential use of District-owned lands to store water, the use of managed recessions, and changes to water shortage planning. We believe that these decisions must be reached in a timely fashion so they can be reflected as accurately as possible in the model simulations in the final comparison of alternatives before selection of a TSP. This will, as mentioned above, contribute to the confidence of stakeholders, and will ensure that the analysis leading to the consultation findings under the ESA are based on the best available technical information.

14. The operational guidance proposes the concept of “make-up” discharges from the lake and flexible band-widths within the regulation schedule. We do not recommend inclusion in the plan of these proposals because they create an additional layer of uncertainty to stakeholders with, in our opinion, relatively little overall benefit. These appear to be mechanisms that allow water managers to modify the approved regulation schedule and make releases based on factors outside of the modeled, decision-making process.
15. The SEIS describes the potential use of State lands as storage sites for excess water, but states that it was not part of the analysis of evaluated alternatives and therefore does not include an effects evaluation as required by NEPA. It appears that the proposal to store water on SFWMD land is not part of this revision to the regulation schedule. If the Corps chooses later to incorporate such actions into a future revision to the schedule, we believe that this would constitute a Federal action. Releasing excess water from the lake is a flood control measure, and appears to be within the Corps’ jurisdiction. This issue should be analyzed in detail before it can be included as part of any revised regulation schedule. Environmental evaluations should be conducted for each property that take into account their water storage capacity, timing of releases, water quality, endangered species issues, and fish and wildlife habitat values.
16. The operational guidance states that periods of Additional Operational Flexibility should be rare events. We believe these events should be invoked only under certain extreme circumstances which would include special management actions such as drawdowns in the Kissimmee Chain of Lakes upstream of Lake Okeechobee, temporary structural impediments to normal operations (e.g., construction or maintenance of structures downstream from the lake), or immediately preceding or following emergencies such as hurricanes. We do not agree that anticipated weather conditions should be posed as a rationale for additional operational flexibility. The established decision trees already incorporate the widely accepted meteorological information available to water managers, including the tributary conditions, Palmer Index, net inflow forecast, El Niño/Southern Oscillation, and seasonal forecasts from the National Weather Service’s Climate Prediction Center. We also ask that the Corps describe in greater detail the deliberation and notification process that would lead to a decision to invoke Additional Operational Flexibility. It is appropriate for interested agencies and the general public to have advanced notification (excluding life-threatening emergencies) and an explanation of what prompted the need, what the objectives are, and the limits of the events.

17. The period of record for the simulations should be extended to include the water years 2000 through 2005. This is important because this period included a drought with the lowest recorded water stage in Lake Okeechobee (8.97 ft on May 23, 2001) and because it also includes the extremely active hurricane seasons of 2004 and 2005.

XI. SUMMARY OF POSITION

The Service has participated in the development and review of alternatives for the current regulation schedule since the initiation of this project. Throughout the evaluation process we provided recommendations involving the refinement and selection of project alternatives based on ecological considerations within Lake Okeechobee, the Caloosahatchee and St. Lucie estuaries, and the greater Everglades ecosystem. Each PDT member agency has advocated the selection of alternatives that best met that agency's goals and mission, and the Service has consistently recommended the adoption of a new regulation schedule that would improve the ecological performance of the existing schedule across the entire spectrum of ecological resource concerns.

The Service believes that the TSP, on balance, will improve ecological conditions within Lake Okeechobee's littoral zone by reducing the extent and duration of extreme high water elevations during wet seasons and storm events. However, this improvement may be partially offset by an increased likelihood of extreme low water levels during dry seasons and local or regional droughts. The St. Lucie estuary will benefit somewhat from the proposed change to the regulation schedule by reducing the excessively high freshwater flows that have plagued that ecosystem in recent years, and by significantly reducing the incidence of low flow events. The proposed change to the schedule will benefit the Caloosahatchee's upper estuary by increasing base flow during dry times that will reduce the number of times the estuary suffers from too high salinity. The Caloosahatchee will also receive less water during wet season releases, decreasing the frequency of some classes of damaging high flow events, but somewhat increasing the severity and duration of the remaining high flow events, which could increase environmental degradation in the lower estuary. Whether or not this tradeoff will result in a net benefit or net impact to the Caloosahatchee estuary is dependent upon the weather conditions of the next 3 years. If the increased tropical storm activity experienced during the past several years continues, both the Caloosahatchee and St. Lucie estuaries will likely continue to be negatively impacted by lake releases. On the contrary, if the next 3 years include a severe or extended drought, the new schedule brings an increased risk of adverse impacts in drying out the littoral zone of the lake.

The Service remains concerned that the selected plan, on average, does not substantially reduce the likelihood of damaging flows to the estuaries. Unfortunately, due to constraints imposed by safety concerns of the HHD, we had to limit our short-term goals to do "no additional harm" to the estuaries, because adequate water storage does not currently exist in the system to reduce flows to a level adequate for estuarine restoration. The Service continues to look at impacts on all natural resources under the current conditions of "shared adversity;" likewise, as additional

storage becomes available, the estuaries should receive an equitable proportion of the “shared improvements.”

The Lake Okeechobee regulation schedule will be revised again around 2010. The current revision of the schedule will provide lessons for improved understanding of how well the current water management infrastructure can handle extreme weather events, and we have already identified several additional analysis tools and methods that should be used in the upcoming revision process. Although this current revision to the schedule does not adequately meet all the needs and desires of the competing lake interests, the next revision to the schedule, with the additional water management infrastructure that is assumed to be in place at that time, will likely approach more closely the goal of balanced and shared adversity as it relates to the multiple objectives of water management in and around Lake Okeechobee.

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Table 1. Performance Measure Output by Alternative for the Caloosahatchee Estuary.

	monthly <450cfs	basin monthly >2800cfs	LOK monthly >2800cfs	total monthly >2800cfs	monthly >2800 <4500	monthly >4500cfs	moving weekly >4500cfs >5 weeks	moving weekly >4500cfs >12 weeks
Target		26	0	26		7		
07LORS_102006	198	40	34	74	45	29	28	0
alt1bS2-aLOWSM	104	39	29	68	32	36	88	0
alt1bS2-mLOWSM	105	39	31	70	35	35	83	13
alt1bS2-T1	116	39	30	69	35	34	66	13
alt1bS2-T2	131	38	25	63	34	29	79	0
alt1bS2-T3	131	37	27	64	35	29	65	0

- = CERP Performance Measure Targets
- = Worse than baseline (07LORS) alternative
- = Best performance of alternatives that are worse than base.
- = Equal to or slightly better than base
- = Much better than base
- = Best

Table 2. Performance Measure Output by Alternative for the St. Lucie Estuary.

	basin		LOK		total	monthly		total
	monthly <350cfs	bi-weekly >2000cfs	bi-weekly >2000cfs	bi-weekly >2000cfs	bi-weekly >2000cfs	>2000cfs	<3000cfs	monthly >2000cfs
Target	207	28	0	28	18	5	23	
07LORS_102006	127	72	52	124	43	31	74	
alt1bS2-aLOWSM	129	71	49	120	36	30	66	
alt1bS2-mLOWSM	129	71	49	120	38	27	65	
alt1bS2-T1	123	70	46	116	37	28	65	
alt1bS2-T2	103	79	54	133	44	31	75	
alt1bS2-T3	103	79	49	128	42	31	73	

= CERP Performance Measure Targets

= Worse than baseline (07LORS) alternative

= Equal to or slightly better than base

= Much better than base

= Best

Table 3. Performance Measure Output by Alternative for Lake Okeechobee.

	Low Stage <11 ft for >80 days	Low Stage <11 ft for >365 days	Low Stage <12 ft for >365 days	Low Stage # days <12.56	High Stage >17 ft for >7 days	High Stage >17.25 ft for >7 days	High Stage >17.5 ft for >7 days	High Stage >15 ft for >7 days	High Stage >15 ft for 365 days	Stage Envelope % time inside
07LORS_053106	3	12	1	2577	9	6	7	2		30.3%
07LORS_102006	5	11	1	2876	11	8	7	2		27.5%
alt1bS2-aLOWSM	6	20	2	4839	4	1	0	0		26.6%
alt1bS2-mLOWSM	7	21	2	4922	2	0	0	0		27.0%
alt1bS2-T1	8	17	2	4909	2	0	0	0		27.3%
alt1bS2-T2	6	19	2	5156	3	1	0	0		25.4%
alt1bS2-T3	6	23	2	5128	2	1	0	0		25.3%

= Worse than baseline (07LORS) alternative

= When all alternatives are worse than baseline, this is the least worst.

= Much better than base

= Best

APPENDIX A



**Florida Fish
and Wildlife
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Commission**

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August 15, 2007

Mr. Paul Souza
U.S. Fish and Wildlife Service
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 33957

**Re: U.S. Fish and Wildlife Service's draft Fish and Wildlife Coordination Act Report for
the Lake Okeechobee Regulation Schedule Study**

Dear Mr. *Souza*,

The Division of Habitat and Species Conservation of the Florida Fish and Wildlife Conservation Commission (FWC) has coordinated an agency review of the U.S. Fish and Wildlife Service's draft Fish and Wildlife Coordination Act (FWCA) Report for the Lake Okeechobee Regulation Schedule Study (LORSS) as based on the Tentatively Selected Plan described and analyzed in the U.S. Army Corps of Engineers' (Corps') revised draft Supplemental Environmental Impact Statement. The FWC has been an active participant throughout the developmental process of the Tentatively Selected Plan for the LORSS, and have worked with your staff extensively during this process. The following comments and recommendations are being provided in accordance with § 662(b) of the Fish and Wildlife Coordination Act, and is not intended as a determination of consistency or inconsistency for purposes of the Coastal Zone Management Act.

Project Description

The Corps proposes to implement an interim regulation schedule for Lake Okeechobee and the Everglades Agricultural Area. The regulation schedule will become part of the Water Control Plan for Lake Okeechobee, which is a feature of the Central and Southern Florida Project. The selected plan will replace the current schedule referred to as the Water Supply and Environment regulation schedule, and is scheduled to be in effect for the next three years, until a new revision to the schedule is implemented in 2010.

In recent years, Lake Okeechobee has experienced above-average lake levels. These extended periods of high water levels within Lake Okeechobee have been identified as causing stress to the structural integrity of the Herbert Hoover Dike, which surrounds the lake, as well as to the lake's natural habitat. Additionally, high water levels in the lake have led to high-volume freshwater releases to the St. Lucie and Caloosahatchee estuaries, causing stress to marine and estuarine habitats. A lower lake regulation schedule is necessary to lessen some of the impacts to the environment from high water levels and high-volume releases, and to accommodate for the dike's structural limitations.

The Tentatively Selected Plan, Alternative 3 (also known as Alt1bS2-T3 or Alt-T3) was identified by the study team to be the alternative that best met the constraints set by the Corps for public safety of the Herbert Hoover Dike, while at the same time minimizing adverse impacts to fish and wildlife resources in the littoral zone of Lake Okeechobee and the St. Lucie and Caloosahatchee estuaries. Alternative 3 is a derivative of earlier, competing alternatives; therefore, a stand-alone description would be difficult without

Mr. Paul Souza
Page 2
August 15, 2007

putting it into context of the overall linear development of the *Alt b* series of alternatives. Major modifications that resulted in Alternative 3 being selected as the TSP include: changing the late-season break points from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address late season hurricanes; including an October 1 breakpoint of 13.0 feet for the bottom of the base flow Zone D0 to provide some protection against low lake levels at the end of the wet season; increasing the Caloosahatchee Level 1 pulse from an average daily rate of 1,600 cubic feet per second (cfs) to 2,000 cfs and Level 2 pulse from average daily rate of 2,300 cfs to 2,500 cfs, thereby allowing for increased releases below 2,800 cfs to reduce higher lake levels and the associated higher releases; and reducing maximum Caloosahatchee discharges from 4,500 cfs to 4,000 cfs when the Lake Okeechobee stage is within the Intermediate (normal to wet) or Low (very wet) bands.

Statement of Concurrence

The FWC concurs with the findings of the draft FWCA Report and appreciates the opportunity to provide input. If you or your staff would like to coordinate further on the recommendations contained in this report, please contact Donald Fox by telephone at 863-462-5190 or by email at Donald.Fox@MyFWC.com.

Sincerely,

Mary Ann Poole

Mary Ann Poole, Director
Office of Policy and Stakeholder Coordination

map/ddf
ENV 1-3-2
Lake Okeechobee_1001
cc: Robert Pace, FWS, Vero Beach
Chuck Collins, FWC, West Palm Beach

APPENDIX B

Evaluation tables for preliminary alternatives.

Table B-1. Performance Measure Output by Alternative for the Caloosahatchee Estuary.

	monthly <450cfs	basin monthly >2800cfs	LOK monthly >2800cfs	total monthly >2800cfs	monthly >2800 <4500	monthly >4500cfs	moving weekly >4500cfs >5 weeks	moving weekly >4500cfs >12 weeks
Target		26	0	26		7		
07LORS	195	40	40	80	46	34	43	0
LORS-fwo	103	40	37	77	44	33	26	0
Alt1a	143	39	33	72	35	37	43	0
Alt1aS1	125	39	32	71	34	37	42	0
Alt1aS2	113	39	32	71	36	35	41	0
Alt1b	144	39	34	73	34	39	73	14
Alt1bS1	135	39	34	73	35	38	70	0
Alt1bS2	114	39	36	75	39	36	69	0
Alt1bS2-A	114	39	36	75	39	36	68	0
Alt1bS2-m	117	39	34	73	36	37	72	13
Alt2a	136	39	40	79	38	41	56	14
Alt2a-A	136	39	40	79	38	41	56	14
Alt2a-B	134	39	41	80	40	41	56	14
Alt2a-m	128	36	34	70	33	37	46	0
Alt2b	174	39	47	86	43	43	145	32
Alt2bS1	144	39	45	84	43	41	103	16
Alt3	199	41	27	68	37	31	91	48
Alt3-B	96	40	21	61	31	30	62	0
alt-4	128	39	34	73	36	37	57	13
Alt4-A	128	39	32	71	34	37	57	13

- = CERP Performance Measure Targets
- = Worse than baseline (07LORS) alternative
- = Much better than base
- = Best

Table B-2. Performance Measure Output by Alternative for the St. Lucie Estuary.

	monthly <350cfs	basin bi-weekly >2000cfs	LOK bi-weekly >2000cfs	total bi-weekly >2000cfs	monthly >2000cfs <3000cfs	monthly >3000cfs	total monthly >2000cfs
Target	207	28	0	28	18	5	23
07LORS	128	72	50	122	44	31	75
LORS-fwo	130	71	43	114	38	30	68
Alt1a	126	71	54	125	43	26	69
Alt1aS1	126	71	52	123	43	25	68
Alt1aS2	126	71	50	121	42	25	67
Alt1b	126	71	51	122	41	28	69
Alt1bS1	126	71	49	120	40	27	67
Alt1bS2	126	71	51	122	42	26	68
Alt1bS2-A	126	71	50	121	42	26	68
Alt1bS2-m	127	70	54	124	36	29	65
Alt2a	129	66	69	135	38	36	74
Alt2a-A	129	66	69	135	38	36	74
Alt2a-B	135	66	68	134	38	36	74
Alt2a-m	118	71	58	129	39	34	73
Alt2b	131	68	63	131	49	25	74
Alt2bS1	136	68	60	128	47	24	71
Alt3	130	72	48	120	36	32	68
Alt3-B	131	72	38	110	34	30	64
alt-4	127	68	48	116	37	30	67
Alt4-A	127	69	46	115	37	30	67

= CERP Performance Measure Targets

= Worse than baseline (07LORS) alternative

= Much better than base

= Best

Table B-3. Performance Measure Output by Alternative for Lake Okeechobee.

	Low Stage <11 ft for >80 days	Low Stage <11 ft	Low Stage <12 ft for >365 days	Low Stage # days <12.56	High Stage >17 ft	High Stage >17.25 ft for >7 days	High Stage >17.5 ft for >7 days	High Stage >15 ft for 365 days	Stage Envelope % time inside
07LORS	3	12	1	2557	9	6	7	2	30.3%
LORS-fwo	5	12	1	3336	11	3	2	2	29.8%
Alt1a	6	14	1	3797	10		2	1	28.2%
Alt1aS1	7	13	2	4062	8		2	1	27.2%
Alt1aS2	7	15	2	4532	8	2	2	1	26.8%
Alt1b	5	20	1	3976	2		0	0	29.0%
Alt1bS1	7	16	2	4300	3		0	0	28.0%
Alt1bS2	6	20	2	4809	2	1	0	0	26.9%
Alt1bS2-A	6	20	2	4809	2	1	0	0	27.3%
Alt1bS2-m	7	22	2	4842	2	0	0	0	27.9%
Alt2a	8	21	2	5229	1	0	0	0	31.7%
Alt2a-A	8	21	2	5229	1	0	0	0	31.7%
Alt2a-B	8	19	2	5141	1	0	0	0	32.1%
Alt2a-m	9	26	2	5776	1	0	0	0	27.8%
Alt2b	6	13	1	4101			0	0	34.0%
Alt2bS1	6	18	2	4613			0	0	29.6%
Alt3	4	10	1	2782	13	9	8	1	23.5%
Alt3-B	6	14	1	3260	15	7	2	0	24.8%
alt-4	9	19	2	4846	2	1	0	0	29.3%
Alt4-A	9	19	2	4841	2	0	0	0	29.6%

= Worse than baseline (07LORS) alternative

= Best performance of alternatives that are worse than base

= Much better than base

= Best

APPENDIX D

Economics

For The Lake Okeechobee Regulation Schedule Study

**U.S. Army Corps of Engineers
Jacksonville District**

November 2007

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1. INTRODUCTION

BACKGROUND

Lake Okeechobee is a large, freshwater lake located in central Florida. The lake is regulated for flood control and water supply purposes and is the heart of south Florida's water management system. During the wet season, lake levels are regulated to reduce potential flood damages by storing enormous volumes of water. During the dry season, stored water is released to support the Everglades ecosystem and to provide water supply to south Florida's municipal and industrial (M&I) users and irrigated agriculture.

Lake levels are actively managed during high and low water conditions. The principal purpose of the Lake Okeechobee regulation schedule (LORS) is to control high water conditions. The potential for heavy rains and severe tropical storms in south Florida requires that the lake be carefully monitored to ensure that water levels do not threaten the structural integrity of the levee system surrounding the lake. When water levels in Lake Okeechobee reach certain elevations designated by the operating schedule, regulatory releases are made through the major outlets to control excessive buildup of water in the lake. The principal outlets are the Caloosahatchee River, which flows westward to Ft. Myers and the Gulf of Mexico; and the St. Lucie Canal, which extends eastward to Stuart and the Atlantic Ocean. Conversely, when lake water levels are excessively low, such as during droughts, the lake undergoes supply-side management (SSM), and releases are restricted to conserve stored water. The outcome of these management measures has been fluctuations in lake levels that are roughly twice the range of historical conditions.

In recent years, three categories of environmental concerns have arisen regarding the operation of Lake Okeechobee. First, extended periods of high lake levels stress the lake's littoral zone, which provides important fish and wildlife habitat. Second, insufficient water releases from Lake Okeechobee to the Everglades have contributed to the deterioration of the Everglades ecosystems. Third, high-water (regulatory) releases from the lake have contributed to ecological deterioration in the Caloosahatchee and St. Lucie estuaries through salinity effects on these sensitive ecosystems.

The U.S. Army Corps of Engineers (Corps) is conducting the Lake Okeechobee Regulation Schedule Study (LORSS) to evaluate the feasibility of modifying the lake's regulation schedule. The purpose of the LORSS is to attempt to formulate alternative lake regulation schedules that will reverse ecological damages while continuing to meet flood damage reduction and water supply needs. The LORSS is being conducted in cooperation with the South Florida Water Management District (SFWMD), the non-Federal sponsor.

In addition to the environmental, flood damage reduction, and urban and agricultural water supply parameters, there are other considerations that enter into decision making regarding management of Lake Okeechobee. These considerations include: (1) commercial navigation across the Florida peninsula via the Lake Okeechobee Waterway, which includes Lake Okeechobee, the Caloosahatchee River, and the St. Lucie Canal, (2) the lake's extensive recreational resources, which include a very popular sport fishery, and (3) commercial fishing on

the lake. In addition, there is public concern that releases of fresh water to the Atlantic Ocean and the Gulf of Mexico are a waste of scarce water resources in a state with increasing water shortages.

1.1 PURPOSE OF THIS INVESTIGATION

This investigation explores the economic consequences of the four LORSS alternative regulation schedules (i.e., lake management plans) and the current regulation schedule. This economic evaluation will focus on agricultural and urban water supply, recreation, navigation, and commercial fishing. Specifically, the differences between the with- and without-project future conditions will be estimated to anticipate the effects of the alternative regulation schedules. Economic effects will be presented in terms of both net national effects (National Economic Development [NED]) and regional effects (Regional Economic Development [RED]). The procedures for estimating NED and RED effects are described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (22 April 2000) Engineering Regulation (ER) 1105-2-100(22 April 2000), and other Corps planning guidance.

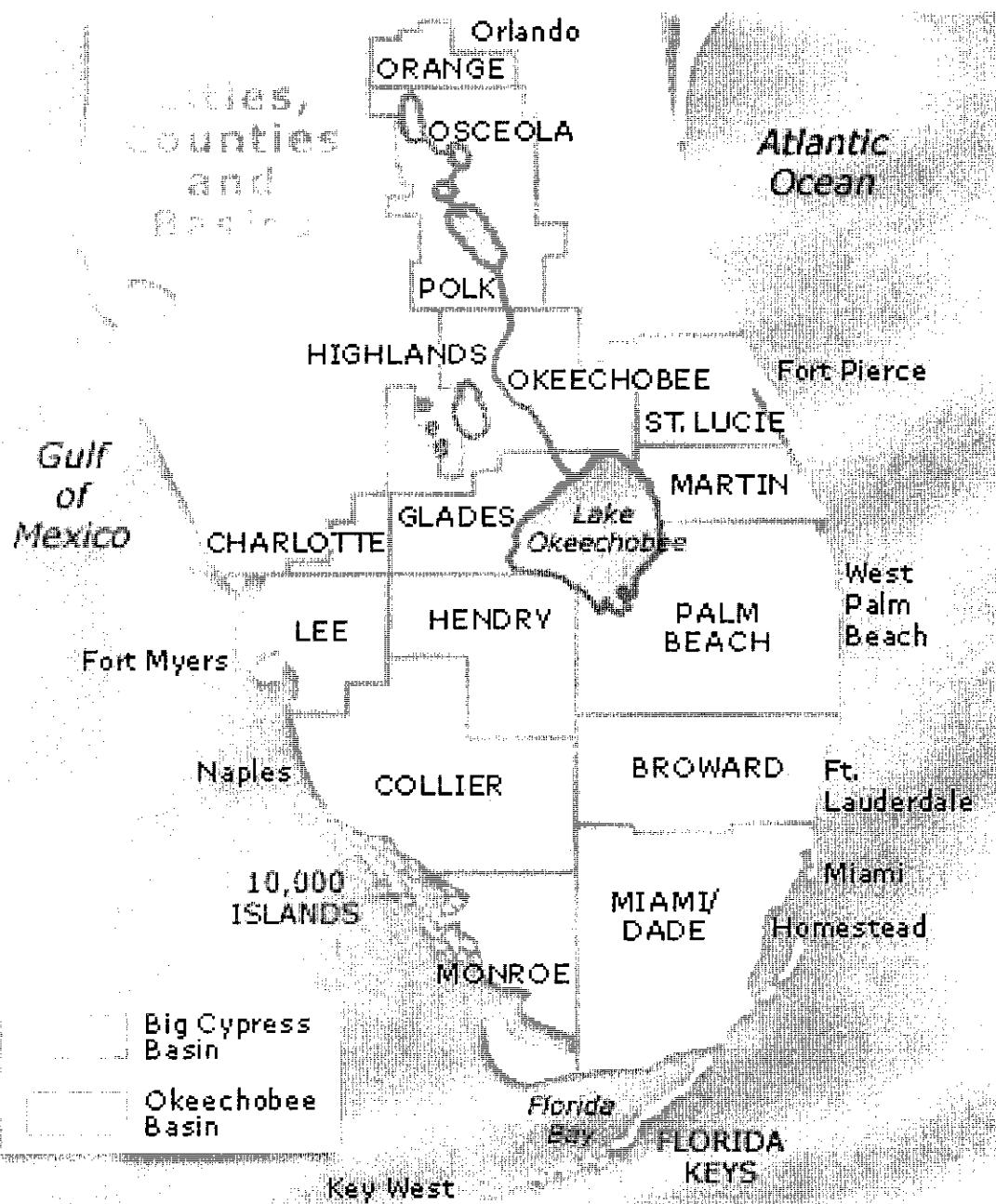
The goal of modifying the regulation schedule is to improve the health of the extensive littoral zone of Lake Okeechobee while maintaining the authorized project purposes of flood damage reduction and water supply. Economic justification of the revised operating schedule is not required. However, the economic impacts of the proposed modification of the current schedule are being estimated to aid Federal decision makers and the non-Federal sponsor in their evaluation of the alternative regulation schedules and selection of the optimal plan.

The LORSS is being conducted in close coordination with the ongoing Central and Southern Florida (C&SF) Comprehensive Review Study. The C&SF project is a system of levees, canals, and water control structures designed to provide flood control, water supply, and other services to south Florida. Lake Okeechobee is a critical element of this system. Although the C&SF project has performed its intended purposes well, it has also contributed to the decline of the south Florida ecosystem. In response to this decline, Congress authorized the C&SF study to investigate structural and operational modifications to improve: (1) the quality of the environment, (2) protection of aquifers, (3) urban and agricultural water supplies, and (4) other water-related purposes.

1.2 STUDY AREA

The LORSS area consists of the 16-county jurisdictional area of the SFWMD (Figure 1-1). Lake Okeechobee extends approximately 30 miles east to west and 33 miles north to south. It encompasses approximately 730 square miles (427,000 acres) at lake elevation 15.5 feet (ft.) National Geodetic Vertical Datum 1929 (NGVD), making it the second largest freshwater lake within the contiguous United States (following Lake Michigan). Although Lake Okeechobee is shallow (average depth is under ten feet) it holds an enormous amount of water, estimated at 5,106,000 acre-feet at the maximum stage under the current regulation schedule (18.5 ft. NGVD). Lake Okeechobee is surrounded by the Herbert Hoover levee system which extends

**FIGURE 1-1
LORSS STUDY AREA**



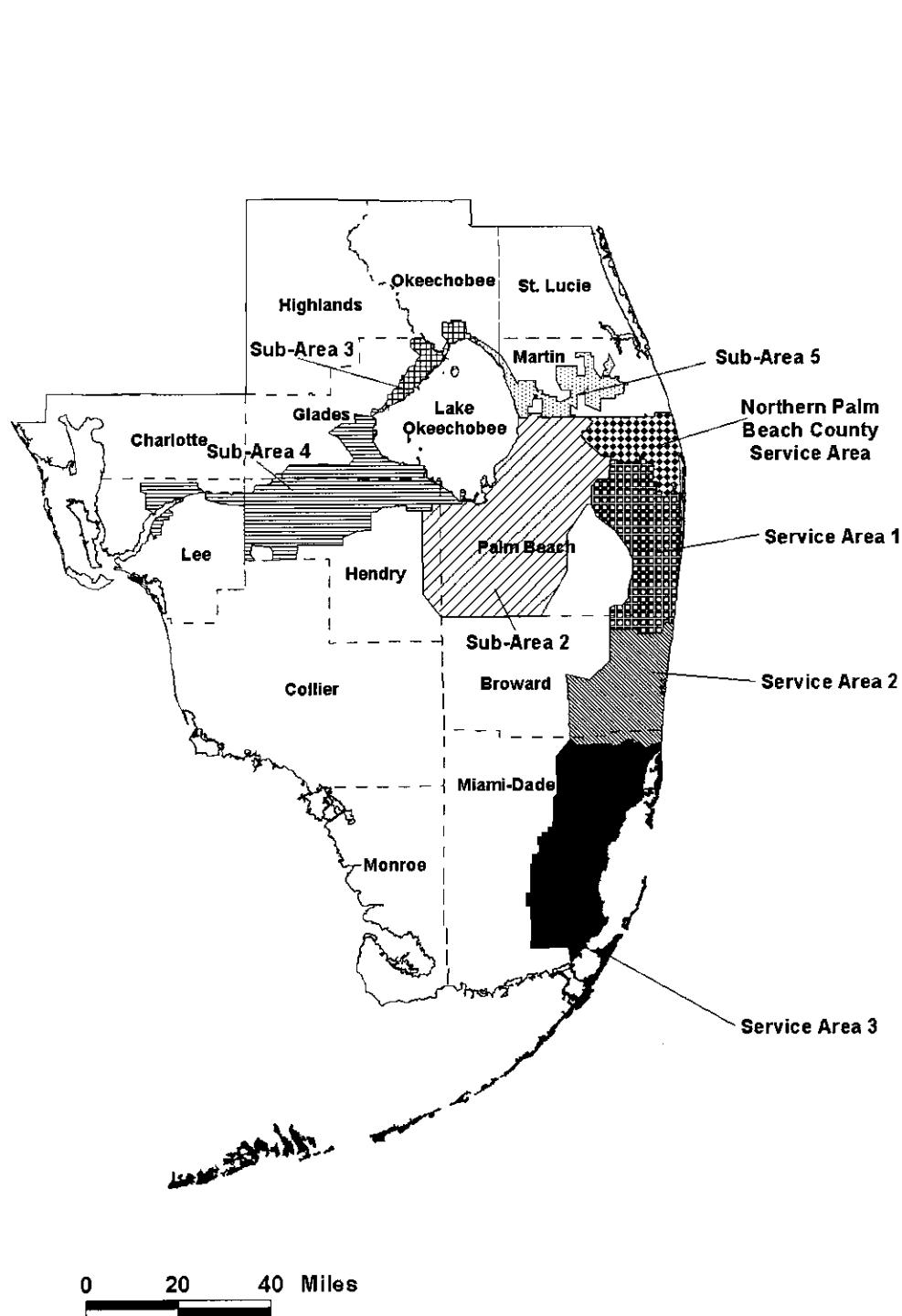
Source: South Florida Water Management District

140 miles with an average elevation of 34 ft. NGVD. The effective limit for water supply withdrawals from the lake is 9.5 ft. NGVD due to physical limitations of the outlet structures. At this stage, Lake Okeechobee retains an estimated 1,884,000 acre-feet of water that is considered inaccessible for water supply purposes. As a result, the maximum available water reservoir storage at 17.5 ft. NGVD would be 3,222,000 acre-feet.

The principal tributary to Lake Okeechobee is the Kissimmee River, which enters the lake from the north. Other tributaries include: Taylor Creek, Nubbin Slough, Nicodemus Slough, and Fisheating Creek. Water leaves Lake Okeechobee through four principal avenues. First, in the south Florida climate, the lake loses tremendous amounts of water to evaporation, accounting for as much as 70 percent of all water losses from the lake. Second, during high lake stages, water is released eastward to the Atlantic Ocean via the St. Lucie Canal. Similarly, high water releases are also made westward to the Gulf of Mexico via the Caloosahatchee River. Finally, lake water is released southward via a system of water supply structures and canals. Major water supply conduits include: the Miami, North New River, Hillsboro, and West Palm Beach canals. These canals convey water for: (1) agricultural uses in the Everglades Agricultural Area (EAA), (2) agricultural and urban water uses in the eastern portions of Palm Beach, Dade, Broward, and Monroe counties, and (3) the Everglades National Park (ENP) via the Water Conservation Areas (WCAs) located southeast of Lake Okeechobee.

Since Lake Okeechobee is so critical to water management in south Florida, the study area encompasses the jurisdictional area of the SFWMD, which includes the lake, its tributary basins to the north, and all of south Florida. However, this analysis of the potential economic effects of the alternative regulation schedules will focus on the water supply planning regions depicted in Figure 1-2, since these areas will experience the majority of the economic effects of the alternative regulation schedules. These areas include the Lake Okeechobee Service Area (LOSA) and the Lower East Coast (LEC) of south Florida. These areas are designated by the SFWMD's South Florida Water Management Model (SFWMM). They include the five sub-areas of the LOSA and the three urbanized service areas of the LEC. Referring to the sub-area designations in Figure 1-2, the five LOSA sub-areas consist of: (1) northern Palm Beach County, (2) the EAA which primarily lies within western Palm Beach County but also eastern Hendry County, (3) the northern lake district, (4) the Caloosahatchee River Basin, and (5) the St. Lucie Basin. The LOSA also includes two Seminole Indian reservations, Brighton and Big Cypress, which are not shown in Figure 1-2. The three LEC service areas primarily lie within Palm Beach, Broward, and Dade counties, respectively. The water supply of Monroe County (not shown in Figure 1-2) is primarily provided by well fields in Dade County (SA3).

FIGURE 1-2
LOSA AND LEC SERVICE AREAS



Source: U.S. Army Corps of Engineers. Central and Southern Florida Comprehensive Review Study. Plan of Study. 1997.

1.3 ALTERNATIVE REGULATION SCHEDULES

Four alternative regulation schedules are currently being evaluated in order to identify the optimal plan to balance the competing management objectives for Lake Okeechobee. Each alternative regulation schedule stipulates the timing, magnitude, duration, and outlets for the regulatory water releases. The regulatory schedules were primarily designed to manage Lake Okeechobee when water levels are high. However, the regulation of high lake levels directly affects the frequency and duration of intermediate and low lake levels, since they determine how much water is stored in Lake Okeechobee during the wet season for use during the dry season. The alternative regulation schedule evaluated in this appendix are: 2007LORSS (No Action), 1bs2-A(alt. A), 1bs2-M (alt. B), T1 (alt. C), T2 (alt. D), T3 (alt. E).

Achieving an optimal regulation schedule is problematic for two principal reasons. First, the large number of competing management objectives complicates the analysis. Second, the climate of south Florida presents significant water management challenges. Distinct wet and dry seasons (beginning in mid-May and mid-October, respectively) and the precipitation potential of tropical storms must be included in all management decisions regarding Lake Okeechobee.

1.4 METHODOLOGY

There were three considerations that dominated the development of methodologies to evaluate the economic effects of the alternative regulation schedules. First, the SFWMM provided a powerful tool to evaluate the hydrologic and economic effects of the alternative schedules. Second, to assess the effects of the alternative regulation schedules, the with- and without-project future conditions must be compared. Third, some economic effects of the alternative schedules must be estimated through economic interpretation of hydrologic and ecological effects of the alternative plans. These considerations and the resultant methodologies used in this investigation are discussed below. Additional information regarding the methodologies is provided in subsequent chapters devoted to specific categories of potential economic effects of the alternative regulation schedules.

1.4.1 South Florida Water Management Model

The SFWMM is the principal analytical tool being used in the LORSS to evaluate and compare the hydrologic effects of the alternative regulation schedules. The SFWMM is a regional-scale, continuous-simulation, hydrologic model that was developed by the SFWMD. It simulates the hydrology and water management of southern Florida from Lake Okeechobee to Florida Bay. As illustrated in Figure 1-3, the SFWMM spans a region that includes most of Florida south of Lake Okeechobee. Of this region, 7,600 square miles are contained in a two-mile by two-mile model grid which is used to simulate system-wide hydrologic responses to daily climatic parameters (rainfall and evapotranspiration [ET]). While some tributaries to Lake Okeechobee, such as the Kissimmee River, are included in the model, they are not simulated with the four square-mile grid cells. Similarly, the Caloosahatchee and the St. Lucie basins, both part of the LOSA, are not included in the grid. However, LOSA sub-areas to the east and south (i.e., the EAA and northern Palm Beach County) are included in the grid. Northern Palm Beach County (LOSA Sub-Area 1) is designated as LEC Service Area 4 in the SFWMM.

The SFWMM simulates infiltration, percolation, ET, surface and groundwater flows, levee underseepage, canal-aquifer interaction, current or proposed water management structures, and

current or proposed operation rules. The model does not allow for changes in land use/cover and associated infrastructure for the simulation period. As a result, the simulations represent the response of a fixed structural and operational scenario to historic climatic conditions. The current version of the model includes climatic data from 1965-2000, allowing (over 11,000 sequential) daily simulations over a 36-year period.

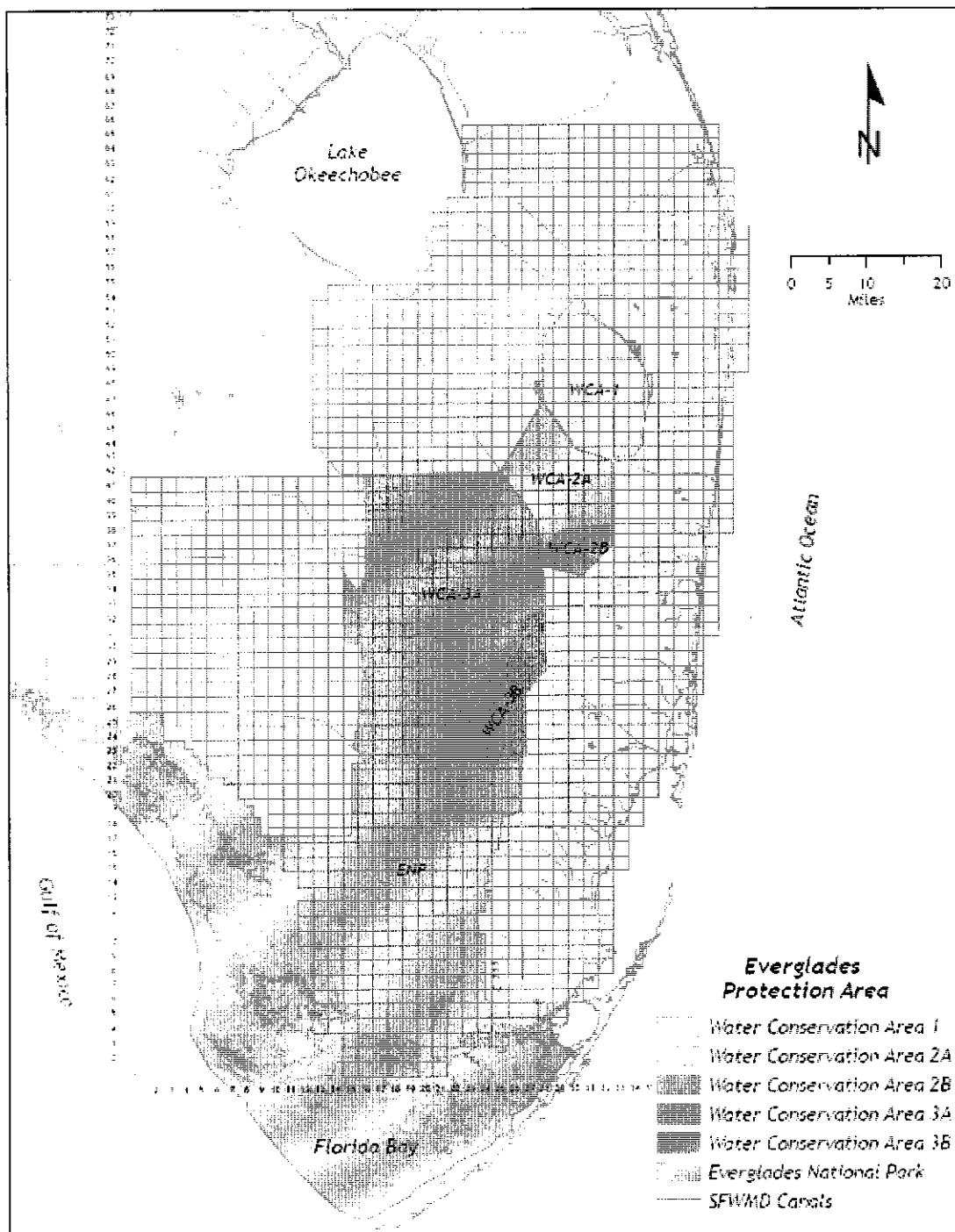
The SFWMM is an operational model whose primary purpose is to assist the SFWMD in optimizing water management and allocation decisions. The model was not designed to conduct economic analysis, but does include many indicators of hydrologic change which can have economic consequences. To assist in estimating the economic effects of water management decisions, the SFWMD developed the Economic Post-Processor (EPP) to estimate the economic effects of cutbacks in agricultural and urban water supply during drought periods. The EPP was used in the LORSS economic analysis to estimate the impacts of the alternative regulation schedules on agricultural and urban water supply.

1.4.2 Comparison of With and Without Conditions

The economic effects of the alternative regulation schedules were determined by comparing the with-project conditions to the current regulation schedule (i.e., the without-project condition). Using the SFWMM as the principal tool for evaluating the economic effects of alternative regulation schedules required some practical modifications to the traditional analytical procedures used in Corps water resource planning studies. In traditional feasibility studies, a probabilistic analysis is conducted to forecast conditions throughout the planning period (typically 50 years), both with and without implementation of a project. “Average annual” economic impacts are estimated by evaluating a range of possible future conditions, weighting the likelihood (i.e., probability) of these conditions by their economic effects, and then statistically combining them. The difference between “average annual” with- and without-project conditions constitutes the net annual economic impacts of the alternative plans.

This type of with- and without-project analysis had to be modified for the LORSS to account for the limitations imposed by the SFWMM. As stated previously, the SFWMM is a simulation model which equally weighs each of the days in the 36-year simulation period. It was not practical to use the SFWMM to determine the likelihood of occurrence of any given hydrologic event for two principal reasons. First, while the 36 years of past climate data are considered representative of future climate conditions, they are of insufficient duration to assign frequencies of occurrence to specific simulated hydrologic events (e.g., 25-, 50-, or 100-year return period events). Second, the regional scale of the SFWMM greatly complicates the assignment of frequencies to specific hydrologic conditions in the regional water management system.

**FIGURE 1-3
SFWMM BOUNDARIES**



Source: South Florida Water Management District.

1.4.3 Hydrologic Changes and Effects

Changing the regulation schedule for Lake Okeechobee has implications for water management throughout south Florida. The most direct effects of the alternative schedules will be on lake levels and on releases from the lake to the Everglades, to the LEC, and to tide via the Caloosahatchee River and the St. Lucie Canal. The potential economic impacts of the alternative regulation schedules are secondary consequences of hydrologic changes associated with the schedules. Figure 1-4 traces the causal linkages between the alternative regulation schedules and the different categories of economic effects.

Some categories of economic impact, such as urban and agricultural water supply effects, can be estimated directly from SFWMM-simulated hydrologic changes associated with each alternative regulation schedule plan. Other economic effects, such as commercial and recreational fishing impacts in the St. Lucie and Caloosahatchee estuaries, are less directly linked to the hydrologic changes resulting from the alternative regulation schedules. In this latter case, the chain of cause and effect includes: the impacts of project-induced changes in water release rates, the impacts of changes in release rates on the productivity of the fisheries, and the impacts of changes in the fisheries on the net income of commercial fishing operations and the quality of recreational fishing experiences. As will become evident throughout this analysis, these chains of cause and effect have important consequences for quantification of the economic effects of the alternative plans. Economic analyses cannot be applied to estimate the value of physical or ecological impacts of the alternative plans if those impacts cannot first be defined and quantified.

1.5 PRIOR STUDIES

The Natural Resources Conservation Service (NRCS) conducted earlier studies that supported this investigation. The NRCS was previously engaged in an interagency agreement with the Corps to perform agricultural water supply impact analyses. NRCS personnel involved in the interagency cooperation provided valuable information and insight for this study.

In addition, the SFWMD performed a series of analyses that served as inputs to this investigation. These include the Simulation of Alternative Operational Schedules for Lake Okeechobee (1998) and a series of SFWMM runs which used the EPP to simulate the economic effects of water supply shortages associated with the alternative regulation schedules.

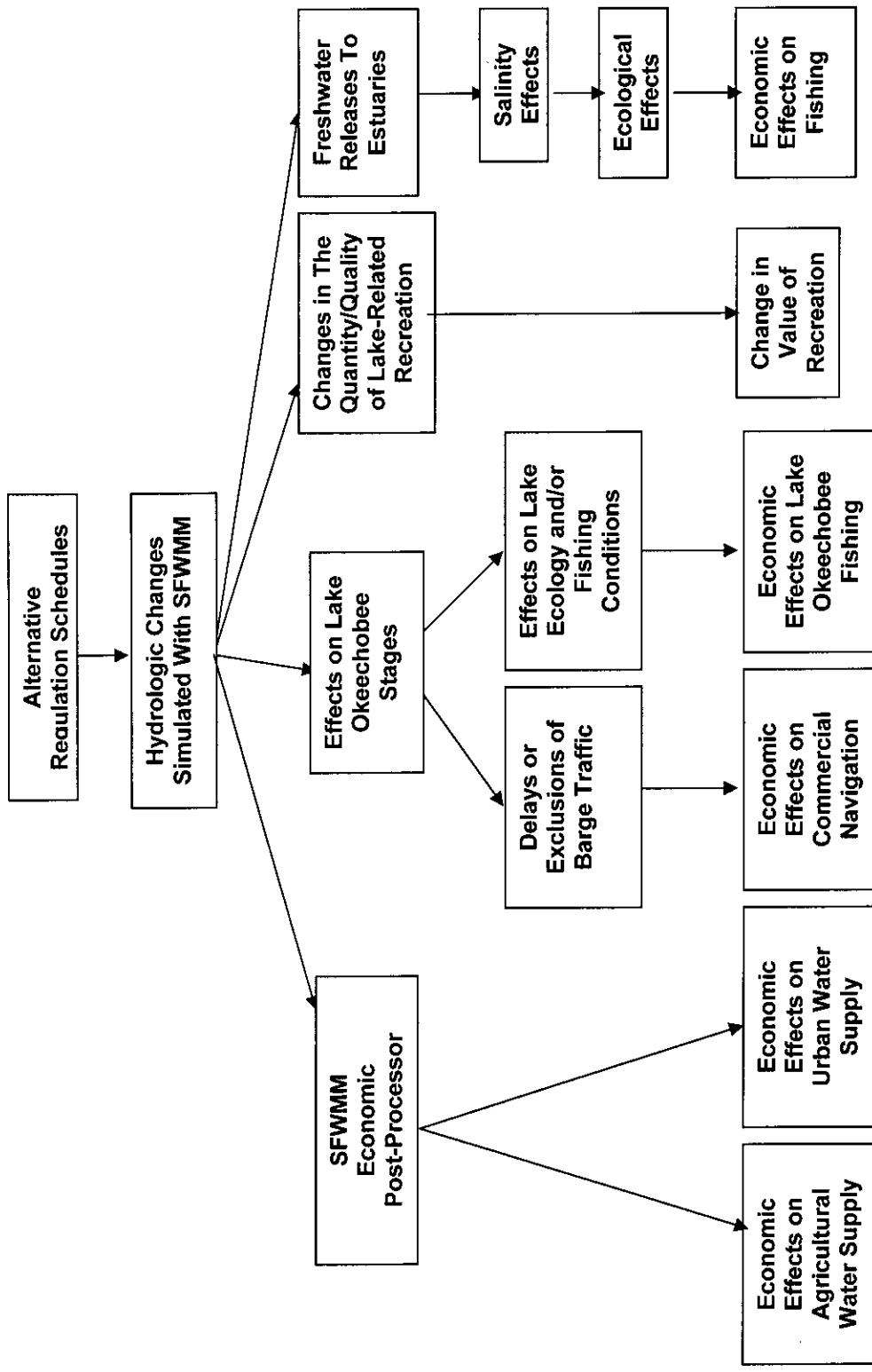


FIGURE 1-4
SOURCES OF ECONOMIC EFFECTS

2. AGRICULTURAL WATER SUPPLY

OVERVIEW

Agricultural activity in south Florida is concentrated in the EAA, to the south and east of Lake Okeechobee; and in rural areas within the LEC, comprised of Dade, Broward, and Palm Beach counties. Principal crops include sugarcane, vegetables, tropical fruit, citrus, sod, ornamental plants, and nursery production. Agriculture in south Florida is supported by the region's abundant rainfall—approximately 59 inches along the LEC and approximately 49 inches in the middle of the peninsula. Unfortunately, this rainfall is not distributed uniformly throughout the year, since the region has distinct wet (May through September) and dry (October through April) seasons. During the dry season, and especially when precipitation is below normal (i.e., droughts), supplemental irrigation is required for much of the region's agriculture.

During droughts, agricultural water users have higher irrigation water demands, since ET is high and soil moisture is depleted. However, during these periods of high water demand, water supplies usually are at their lowest levels. Consequently, agricultural water users do not always receive as much water as they would like. Irrigation water shortages can have negative economic consequences for farmers, since water stress can reduce crop yields and can induce crop mortality. Residential water users in urban areas of the LEC can also experience shortages of irrigation water, which is needed for urban and suburban landscaping. These shortages can also have negative economic consequences for landscaping and can result in diminished aesthetics (i.e., brown lawns) and renovation or replacement costs for expired turf or ornamental landscaping.

The LOSA, which includes the EAA, is more dependent on agricultural water supplies from Lake Okeechobee than the LEC. During periods of normal rainfall, agricultural and urban water users in the LEC do not require supplemental water from the lake. In addition to rainfall, the LEC receives significant well field recharge via easterly seepage from the WCAs under the north-south levee system which serves as a boundary between the LEC and the Everglades. However, during prolonged drought events, significant volumes of water from Lake Okeechobee can be required by the LEC to supplement local water supplies and to prevent saltwater intrusion into well fields.

The potential effects of the alternative regulation schedules on agriculture are based on the magnitude and frequency of irrigation water shortages. The economic effects of the alternative regulation schedules are the differences between the expected crop losses resulting from agricultural water shortages under with- and without-project conditions.

2.1 AGRICULTURE IN THE LAKE OKEECHOBEE SERVICE AREA

As described in the following profile of south Florida agriculture, there is substantial agricultural activity in the LOSA and the LEC. Two levels of detail are presented in this study regarding land uses in the EAA (the largest area within the LOSA) and the LEC. Detailed information about acreages and crop mixes from several sources is presented for the EAA and the LEC. However, the estimates of agricultural land use for the with- and without-project conditions

utilize less detailed and broader land use categories for the 2000 scenarios contained in the SFWMM and EPP.

The utilization of broader land use categories in estimating economic effects reflects two practical considerations: (1) the need to forecast future agricultural land uses and (2) the spatial resolution of the SFWMM, which is the primary analytic tool for evaluating the alternative regulation schedules. Agricultural land uses can be extremely difficult to forecast, since crop types can change from year to year, and larger scale land use changes (such as the conversion of agricultural land to urban and suburban uses) can occur rapidly as well. As a result, it is more realistic to forecast future land uses with broad land use categories. Regarding the limitations of the SFWMM, the four square-mile resolution of the model's grid cells is coarse relative to the assessment of agricultural water supply impacts of the LORSS alternative schedules. The model was designed to simulate the hydrology of south Florida. Land use patterns in south Florida represent static inputs to SFWMM hydrologic simulations. The hydrologic implications of changes in land use can only be evaluated in this model by comparing the results of separate simulations. The SFWMM land use estimates for 2000, which are utilized in this investigation, are critical components in the analysis of with- and without-project conditions. The estimates affect most aspects of water management in south Florida, including the economic aspects. These estimates were utilized by the EPP in the runs conducted for this study and are presented below.

Table 2-1 presents the acreages of irrigated agriculture in the sub-areas of the LOSA. As indicated in this table, there are 742,668 acres of irrigated land in the LOSA. Agricultural activities in the LOSA sub-areas are described below. See Figure 1-3 for the sizes and locations of the sub-areas.

**TABLE 2-1
LOSA IRRIGATED ACREAGE**

LOSA Sub-Area	Irrigated Acreage
1. EAA	541,878 ¹
2. North Shore	13,380 ²
3. Caloosahatchee Basin	138,337 ³
4. St. Lucie Basin	49,073 ⁴
Total LOSA	742,668

Sources:

¹: Hall, C.A. Lake Okeechobee Supply-Side Master Plan. SFWMD. 1991.

²: SFWMD Long-Range Demands for the Caloosahatchee Basin. 1997.

³: SFWMD Long-Range Demands for the St. Lucie Basin. 1997.

2.1.1 Everglades Agricultural Area

The EAA encompasses an area of approximately 593,000 acres. As indicated in Table 2-2, the EAA contains approximately 542,000 acres under cultivation. Sugarcane is the dominant crop, accounting for 90 percent of the land under cultivation. The remaining ten percent under cultivation is occupied by rice, row crops, and sod. The row crops include corn, celery, radishes, and lettuce.

TABLE 2-2
AGRICULTURAL LAND USES IN THE EAA

Crop	Acreage	Percent of Total
Sugarcane	436,856	86.8%
Miscellaneous	18,514	3.7%
Row Crops	21,107	4.2%
Sod	26,912	5.3%
Total EAA	493,389	100%

Sources: Hendry and Palm Beach County Tax Appraisers, 2003

¹ IFAS Extension Agent, Palm Beach County.

The EAA is very well suited to sugar production. There are thick organic muck soils and adequate water supplies from precipitation and from Lake Okeechobee via the EAA network of water supply canals. Multiple crops can be harvested from a single planting. Planting typically occurs in the autumn months. The planted cane will be ready for harvest in approximately 16 months. The root stock is left in place, and the first regrowth (i.e., ratoon) can be harvested again in 11 months. Again, the root stock is left in place, and a second ratoon will be ready in another 11 months. Some farms will harvest up to four ratoons, but yields decline with each successive ratoon. As a result, many farmers replant after the second ratoon in order to keep cane yields high.

The harvest season is from October to March. After harvesting the last ratoon, farmers must decide whether to replant immediately or leave the field fallow until the following autumn. If there is successive planting, more cane can be harvested the following year. However, if the field is left fallow, yields would be higher once the field is replanted. Many farmers will balance these competing incentives by replanting half of the field and leaving the other half fallow. For this reason, Alvarez (1997) estimates that following crop distribution would be typical of many sugarcane farms: plant cane (25%), first ratoon (25%), second ratoon (25%), fallow (12.5%), and roads, canal, ditches (12.5%). Sugarcane grown in the EAA is converted into raw sugar at the seven sugar mills found in the area. Sugarcane must be milled rapidly after it has been harvested to avoid degradation of its sugar content. The raw sugar is then shipped to sugar refineries located throughout the United States where it undergoes additional processing.

The EAA is not uniformly well suited to sugar production. In general, land that is closer to Lake Okeechobee (i.e., more northern) is better suited for sugarcane than areas to the south. The areas close to Lake Okeechobee are protected from frosts by the climatic influence of the lake. In addition, the muck soils are deeper in the northern part of the EAA. Consequently, soil subsidence is not as much of a problem as in areas with relatively shallow soils in the southern EAA. Subsidence occurs when the land is drained and the organic soils begin to oxidize. The surface elevation of the land subsides toward the underlying limestone bedrock. In some southern zones of the EAA, subsidence has reduced the soil layer to less than six inches, the point at which farming is typically no longer profitable. Another negative aspect of subsidence is that as the soil layer thins, the soil chemistry changes, and the application of additional nutrients (i.e., fertilizer) is required.

Most of the non-sugar crops in the EAA are grown by farmers who also grow sugarcane. Many farmers rotate their vegetable cultivation between celery and sweet corn; others rotate lettuce and

sweet corn. Sod is grown primarily in the southern portion of the EAA, an area of declining suitability for sugarcane due to subsidence. Rice cultivation is small, but it could grow in importance. Rice cultivation is being encouraged by the University of Florida's Institute for Food and Agricultural Science (IFAS) to retard soil subsidence. Rice production is also recommended by the SFWMD as a way to reduce phosphorus loading into the Everglades, since rice requires less fertilizer than sugarcane. However, under prevailing market conditions rice profitability is low relative to sugarcane.

The spatial resolution of the SFWMM is too coarse to fully reflect the above land use profile of agriculture in the EAA. For example, the SFWMM assigns all of the EAA acreage to sugarcane (i.e., all of the grid cells are designated as sugarcane), since the non-sugar crops in the EAA are spatially diffuse and do not dominate a single grid cell. Therefore, only sugarcane is registered under the model's four square-mile grid cell resolution. As a result, the information in Table 2-2 is consistent with the SFWMM land use estimates of total acreage, but not acres devoted to sugarcane cultivation. As will be evident later in this report, the model's homogenization of agriculture in the EAA has implications for the calculation of economic impacts of the alternative regulation schedules.

The land use projections used in the SFWMM estimate that sugar cultivation (and perhaps agriculture in general) in the EAA will decrease in the future, from 529,920 acres in 1990 to 491,520 acres by 2010. The projected decrease is due primarily to the SFWMD's purchase of agricultural land for Stormwater Treatment Areas (STAs), and perhaps to anticipated soil subsidence as well.

2.1.2 Caloosahatchee and St. Lucie Basins and the North Shore

Agricultural land uses for the Caloosahatchee and St. Lucie basins are presented in Tables 2-3 and 2-4. The agricultural water needs in these basins that are not met with local sources are met with water released from Lake Okeechobee into these two outlet waterways. The Caloosahatchee Basin is an area of expanding agricultural activity with increasing agricultural water demands. No land use data was available for the North Shore sub-area.

**TABLE 2-3
AGRICULTURAL LAND USES IN THE CALOOSAHATCHEE BASIN
1997**

Crop	Acreage	Percent of Total
Citrus	78,113 acres	56 %
Sugarcane	50,359 acres	36 %
Vegetables	8,091 acres	6 %
Sod	1,296 acres	1 %
Ornamentals	478 acres	<1 %
Total	138,517 acres	100 %

Source: SFWMD. Draft Long-Range Demands for the Caloosahatchee Basin. 1997.

TABLE 2-4
AGRICULTURAL LAND USES IN THE ST. LUCIE BASIN
1997

Crop	Acreage	Percent of Total
Citrus	43,071 acres	88 %
Vegetables	5,538 acres	11 %
Sugar Cane	449 acres	1 %
Nursery	15 acres	<0.1 %
Total	49,073 acres	100 %

Source: SFWMD. Draft Long-Range Demands for the St. Lucie Basin. 1997.

2.2 AGRICULTURE IN THE LOWER EAST COAST

The three service areas of the LEC also contain large areas of agriculture. Table 2-5 presents the 1990 and 2010 agricultural land use patterns contained in the SFWMM for the LEC service areas, including northern Palm Beach County (SA-4). These values were extracted from the SFWMM by the EPP. The EPP considers only those SFWMM land use categories for which economic effects of water shortages can be generated. As indicated in Table 2-5, the EPP uses six broad categories of land use: urban, nursery, golf courses, low-volume (LV) irrigated agriculture (such as citrus and avocado), overhead (OV) irrigated agriculture (such as tomatoes), and other agriculture (including sod, sugarcane, and rice). As suggested in this table, tomatoes are intended to represent truck vegetables grown with OV irrigation systems. The categories of urban (turf) and golf (which is primarily suburban) land uses are included because these lands are maintained with irrigation water that is supplemented directly or indirectly with water from the regional water supply system. While these two land uses are not agricultural, they will be included in the discussions of agricultural water supply throughout this report.

2.3 AGRICULTURAL WATER MANAGEMENT DURING SHORTAGES

To estimate the potential damages associated with shortages in agricultural water supply, it is necessary to understand how irrigation water supplies are managed during drought periods. Agricultural water use during droughts is the result of regional decisions made by water management institutions, such as the SFWMD, and local decisions made by water users, including individual farmers. These two levels of water management decision making during droughts are discussed below.

2.3.1 Regional Water Management

The SFWMD monitors hydrologic conditions throughout south Florida. Current hydrologic and water use data is compared to historic data to determine: (1) whether present and anticipated water supplies are sufficient to meet the present and anticipated needs of water users and (2) whether serious harm to the region's water resources can be expected, including saltwater intrusion into freshwater aquifers or adverse fish and wildlife effects.

Factors considered in estimating present and anticipated water supplies include:

- Historic, current, and anticipated levels in surface and ground waters,
- Historic, current, and anticipated flows in surface waters,
- The extent to which water may be transferred from one source to another,

- The extent to which water use restrictions might enhance supplies,
- Historic, current, and anticipated demands of natural systems, and
- Historic, current, and anticipated seasonal fluctuations in rainfall.

Factors considered in estimating present and anticipated water demands include:

- Estimated current, and anticipated demands of permitted and exempt users,
- Demands of users whose water supply is established by Federal law,
- Anticipated seasonal fluctuations in user demands, and
- The extent to which user demands may be met from other sources.

When the current or future water supplies are not expected to meet water demands, the SFWMD may institute a series of progressively more severe conservation (demand management) measures to conserve water supplies. The SFWMD developed the Water Shortage Plan in 1982 following a severe drought during which Lake Okeechobee reached its all-time record low level of 9.75 ft. NGVD. The plan provides specific guidelines for water restrictions, which are based on the type of use and the severity of the drought. Included within the plan are four progressively more severe water shortage phases (I-IV) which initially request and later require cutbacks in water use throughout south Florida. Included within the Water Shortage Plan are water use reductions which are expected to range up to 15 percent of estimated demand under Phase I and up to 60 percent of estimated demand under Phase IV.

Shortage declarations by the SFWMD can be triggered by salinity intrusion into coastal aquifers threatening utility well fields or by low lake levels in Lake Okeechobee relative to seasonal norms. The declarations are typically continued until it is clear that the imbalance between water supplies and water demands is resolved, avoiding to the extent possible an on/off whipsaw of shortage declarations.

If droughts are localized, the SFWMD will attempt to manage the regional water supply system to move water from areas of surplus to areas of deficit. The shortage phase declarations can be scaled to the municipal, utility, county, service area, or regional level commensurate with the extent of the water shortage. For regional droughts, such as those triggered by low Lake Okeechobee levels, the water shortage phases are instituted to reduce water demand on a system-wide basis. To date, the specific use restrictions of the Water Shortage Plan have been invoked three times: 1982, 1985, and 1989 (Hall, 1991).

The four phases of water supply shortages in the Water Shortage Plan stipulate cutbacks by water users in the LEC, including agricultural water usage. However, the phased restrictions in the Water Shortage Plan have not been applied to agriculture in the LOSA. Agricultural water users in the LOSA are subject to SSM for Lake Okeechobee. The required agricultural water use restrictions of the Water Shortage Plan are assumed to have been met when LOSA water users comply with Lake Okeechobee's SSM plan.

During severe droughts, water levels in Lake Okeechobee drop as inflows are exceeded by water losses from releases and evaporation. If water levels fall sufficiently, SSM is instituted for the Lake Okeechobee. The amount of water available for use is a function of anticipated rainfall,

evaporation, and water needs (for the balance of the dry season) in relation to the amount of water currently in storage. SSM begins when lake levels fall below the watch and warning levels and enter Zone A. The upper limit of Zone A represents a storage amount sufficient to meet all demands in the following year provided that all basins receive at least 100 percent of normal rainfall during the year. Each of the zones represents storage levels with assigned probabilities of shortage. For example, if the stage in the wet season is in Zone A or lower, the area has a 50 percent probability of a water shortage in the following winter and spring (i.e., dry season).

The SFWMM is used to calculate weekly water allocations for each agricultural water user in the LOSA. Available water supplies are estimated based on lake levels and evaporation and rainfall estimates. Allocations are then made by comparing normal water requirements with available water supplies.

The SSM rules for the EAA are bounded by SFWMD policy which commits to supplying a minimum of one-third of the supplemental irrigation needs for agriculture in this area. This lower limit of agricultural water supply is reflected in the SFWMM. This policy may effectively preclude crop mortality in the EAA during dry periods and limit drought effects on agriculture to reduced crop yields.

2.3.2 Local Water Management

For each crop and irrigation method in the LEC, the water use of farmers is specified by the Water Shortage Plan. Farmers in the LOSA have more flexibility in making water management decisions. Under SSM, water allocations to agricultural users in the LOSA are progressively cutback as shortages become more severe (Zones A to D). However, the SFWMD Governing Board may allow agricultural users to borrow against their seasonal allocation in the first four months of the dry season. The behavior of LOSA farmers in the face of water supply shortages is based on the vulnerability of their particular crops to water stress and the value of those crops. If plants do not receive sufficient moisture from precipitation or irrigation, particularly during critical stages in the growing season, ET is reduced, and growth rates and yields can be significantly affected. Some crops are more vulnerable to water stress than others. For example, sugarcane is more tolerant to water stress than most vegetables. As a result of water stress, the sugar content of the cane will be reduced, but the entire crop will not be lost. In fact, some sugar farmers prefer dry conditions immediately prior to harvest, since it increases the sugar content of the cane. Vegetables, on the other hand, can quickly suffer large yield effects and crop mortality in response to stress from water shortages.

Changes in crop yield are a critical determinant of farm income and can induce changes in crop mix or farming practices. For farmers in the EAA who grow sugar and vegetables, their decision making during water shortages is based on expected crop-specific responses to water stress and the relative value of each crop. Farmers will allocate water on their lands based upon the greatest marginal value of the scarce irrigation water. When water allocations from the regional water system are reduced, farmers will typically give vegetables priority over sugar cane (Scheneman, 1997), because of the sensitivity and value of vegetable crops. As a result, vegetables and other non-sugar crops in the EAA are not expected to experience as great a cutback during shortages, since sugarcane will be the primary recipient of irrigation cutbacks.

Interviews conducted with a variety of experts on EAA agriculture indicate that farmers will generally borrow as much water as they can against their future allocation in order to fully satisfy the water needs of their crops for as long as possible (Personal Communications: Alvarez, 1997; Scheneman, 1997). Essentially, farmers in the EAA will accept the risk of extreme cutbacks later in the season in order to meet their full irrigation needs early in the season. Farmers weigh their present needs against their future needs with careful consideration. The type of crop, timing during the growing season, and anticipated cutbacks are included in their decision making. This risk-accepting behavior is supported by experience. During the 1981-1982 drought, widespread borrowing against seasonal water allocations by farmers in the EAA was reinforced by above-normal rainfalls later in the growing season, mitigating the deferred impacts of the drought (Hall, 1991). The SFWMD's policy of meeting at least one-third of the supplemental irrigation requirements of farmers in the EAA may give additional impetus for farmers to borrow against their seasonal water allocations.

Reductions in delivery of water from Lake Okeechobee to south Florida agriculture may or may not result in economic losses to farmers. The 1981-1982 experience cited above is testament to this uncertainty. There are a variety of factors which determine the actual economic impacts of shortages, including antecedent conditions, local precipitation during and after the cutbacks, crop types, and the timing of the cutbacks with respect to the growing season. Interviews with LOSA agricultural experts also suggest that farmers will not significantly modify their production activities during shortages. When shortages do occur, the water stress associated with irrigation cutbacks will result in yield reductions for the entire crop, since water stress will be uniform across the entire irrigated area. Therefore, the unit costs of crop production will not change significantly for different yield levels. Regardless of whether the crop is 100 percent, 80 percent, or 50 percent of potential yield, the unit costs of crop production will be the same. As will be evident later in this report, this has important implications for estimating the NED impacts of agricultural water supply shortages resulting from the alternative regulation schedules.

2.4 ECONOMIC POST PROCESSOR DEVELOPMENT AND FUNCTION

The SFWMD has developed an EPP to assess the monetary effects of agricultural and M&I water supply shortages. The EPP, which is embedded in the SFWMM, was designed to estimate the agricultural and M&I water supply impacts of physical or operational changes in water management in south Florida, such as modifying the regulation schedule for Lake Okeechobee. The utility of the EPP for estimating the potential economic effects of the alternative regulation schedules is examined below.

The EPP was originally developed to estimate the benefits of structural and/or operational improvements to the regional water supply system by monetizing the value of south Florida's unmet demands for agricultural and M&I water supply. As illustrated in Figure 2-1 and described below, the agricultural element of the EPP was developed through a five-part process.

2.4.1 Development of the Agricultural Field Scale Irrigation Requirement Simulation Model

The Agricultural Field Scale Irrigation Requirement Simulation (AFSIRS) was developed at the Agricultural Engineering Department of the University of Florida (Smajstrla, 1990). This model predicts water requirements for maximum crop yields. It does not predict crop yields, but

instead calculates the quantity and frequency of irrigation necessary to avoid water stress to crops. The program contains the data necessary to model all of the commercially important crops in Florida under various irrigation schemes and with a wide variety of soil types.

AFSIRS calculates irrigation requirements and ET rates as a function of crop type, soil type, irrigation system, growing season, and climatic conditions. The model assumes that irrigation requirements are met from the unsaturated zone through rainfall or supplemental irrigation. As illustrated in Figure 2-1, the model draws upon four data files. The user specifies three sets of input parameters for the agricultural plot: soils, crops, and irrigation systems. These inputs are combined with time-series precipitation data and simulated potential and crop-specific ET and potential ET (PET) rates respectively. The model then calculates how much water is required by the selected crop at a particular point in its growing season under specific soil and climatic circumstances. AFSIRS has been successfully tested and applied in south Florida. The SFWMM contains an AFSIRS module that is used to estimate daily water requirements of irrigated agriculture in the LOSA and the LEC.

2.4.2 Modification of the Agricultural Field Scale Irrigation Requirement Simulation Model for Drought Applications

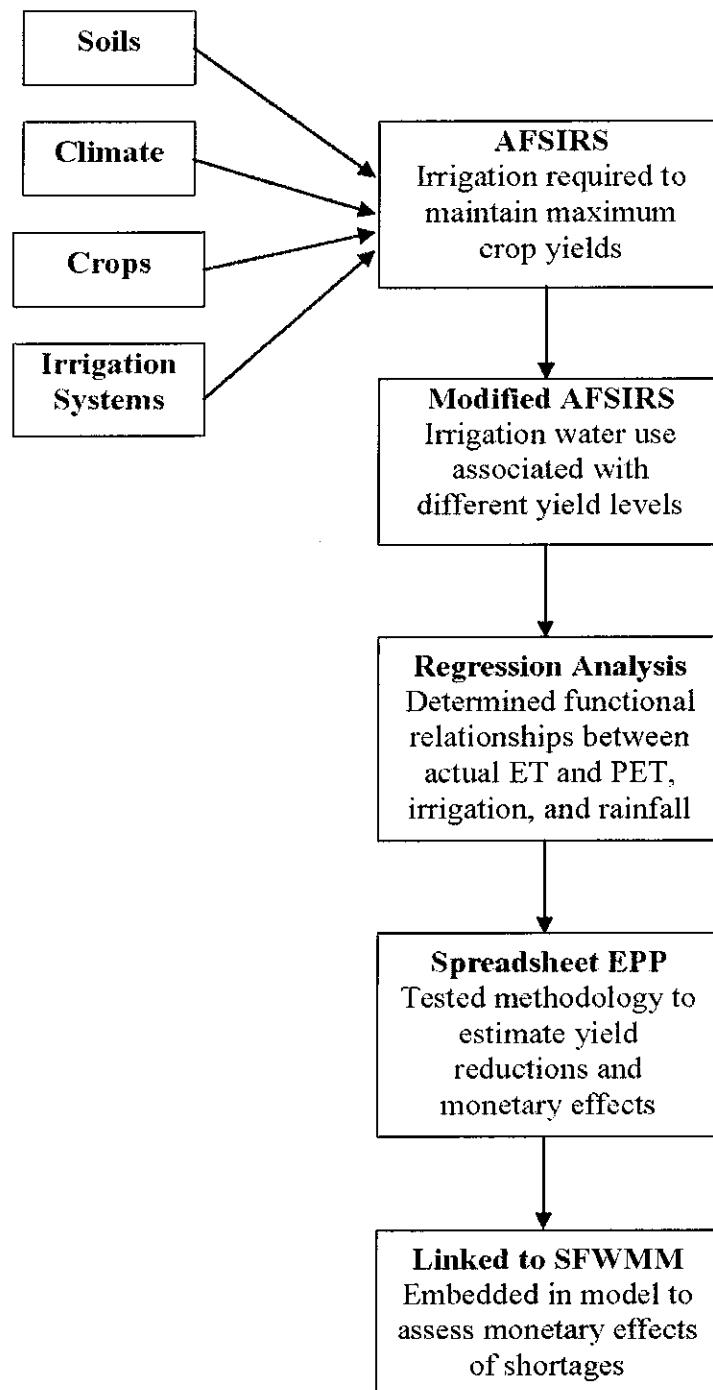
Thompson and Lynne (1991) of IFAS modified the AFSIRS program for drought impact analysis. Among the modifications made by Thompson and Lynne was the introduction of the Stewart equation into the model. The Stewart equation relates the difference between actual ET and PET to changes in crop yield. The logical basis for the Stewart equation is that plants reduce their transpiration when they are water stressed, and this reduction is an indicator of stress-induced effects on crop yield. The Stewart equation is as follows:

$$1 - (Y_{act}/Y_{max}) = \beta(1 - ET_{act}/ET_{max})$$

where:

Y_{act}	= actual crop yield per acre (simulated)
Y_{max}	= maximum crop yield per acre
β	= crop specific output per irrigation level (Beta coefficient)
ET_{act}	= actual evapotranspiration per acre (simulated)
ET_{max}	= potential evapotranspiration (PET)

FIGURE 2-1
DEVELOPMENT OF THE AGRICULTURAL ELEMENT
SFWMM ECONOMIC POST-PROCESSOR



According to Thompson and Lynne, the Stewart equation is widely accepted. The crop-specific Beta coefficients (β_i), which relate water stress to crop yields, are based on research conducted for the Food and Agricultural Organization of the United Nations (Doorenbos and Kassam, 1979). The Beta coefficients depend on the crop type and growth stage being modeled. Thompson and Lynne caution users of this model that the Beta coefficients contained in the program have been obtained from experimental data. For annual crops, single coefficients are included in the model for four growth stages: early vegetative, flowering, yield formation, and ripening. For perennials, it is more difficult to produce coefficients for specific growth periods. For example, it is well known that citrus is sensitive to water shortages during flowering. However, the actual flowering period will vary with climate and with soil moisture. This is problematic for AFSIRS, since it calculates irrigation requirements using the calendar date as a key to crop growth stage.

In the modified AFSIRS program, the user must specify actual yields (Y_{act}) as a proportion of the unconstrained yield (Y_{max}). The model uses the Stewart equation to simulate actual ET (ET_{act}). In the model, ET_{act} is drawn from the unsaturated zone, and the water comes from rainfall or supplemental irrigation. Precipitation estimates contained in the climatic data file are used by the modified AFSIRS program to compute the supplemental irrigation required for the specified crop yields.

Thompson and Lynne (1991) attempted to validate the modified AFSIRS program. This was problematic however, since there were no subsequent agricultural droughts with which to compare the model's predictions. Instead, the model was tested against three crop-growth models which have been tested extensively in north Florida. The modified AFSIRS model generated results which were similar to the other models. Improvements were subsequently made to the model during the calibration process.

2.4.3 Regression Analysis

The SFWMD used the modified AFSIRS to determine the functional relationships among actual ET and PET, irrigation levels, and precipitation for a wide variety of crop and irrigation schemes (March, 1996). This was done by performing a series of model runs, specifying a range of different actual yields (Y_{act}): 100%, 75%, 60%, 50%, 40%, and 25%. This generated a series of simulated ET_{act} values. Regression equations were then computed to relate modeled monthly ET to monthly PET, rainfall, and net irrigation. The general functional form of the regression equations is double (natural) logarithmic:

$$\ln (ET_{ijkl}) = \alpha + \beta_1 \ln (PET_i) + \beta_2 * \ln (Raadj_i) + \beta_3 * \ln (Iradj_{ijkl})$$

where:

ET_{ijkl} = actual ET in month i of crop j on soil type k for yield level l

PET_i = Modified Penman-Monteith potential ET in month i

$Raadj_i$ = measured rainfall in month i

$Iradj_{ijkl}$ = simulated net irrigation in month i of crop j on soil type k at yield level l

(Note: β_i here are regression coefficients, not the crop output factors in the Stewart equation)

2.4.4 Spreadsheet Prototype

The SFWMD developed a spreadsheet prototype of the EPP. During periods when available irrigation water supplies are less than what the AFSIRS model predicts is necessary to support maximum crop yields, the EPP estimates the potential reduction in agricultural revenues using the functions described above. The lower crop yields estimated using the regression functions are compared against maximum yields to determine changes in yield per acre. These values are then multiplied by the number of acres to estimate changes in total crop outputs. Crop outputs are multiplied by market prices to compute the potential revenue effects of water shortages.

2.4.5 Linkage to South Florida Water Management Model

Once the spreadsheet prototype was successfully tested, the SFWMD embedded the EPP within the SFWMM. The SFWMM outputs of PET, irrigation water supply, and precipitation were combined with the land use profile (agricultural) for input to the EPP. The AFSIRS module determines the irrigation requirements for specific crops in particular locations. When irrigation water supply is insufficient to meet crop requirements, the EPP estimates the potential reduction in total revenues which could result from water shortages.

2.5 ECONOMIC POST-PROCESSOR ASSESSMENT

The EPP model has some theoretical and experimental components. When the U.S. Department of Agriculture (USDA), NRCS was supporting the Corps in its attempt to estimate the effects of the alternative regulation schedules on agricultural water supply, the staff considered using historical data to develop crop-specific relationships between crop yields and irrigation water shortages. The NRCS reviewed the past 25 years of agricultural water supply data available from the SFWMD and compared this information with historic data on crop yields in south Florida. According to NRCS staff, there was only one drought year during this period (i.e., 1982) when there was a significant shortage of irrigation water in south Florida. During that year, crop yields were significantly lower than other years. However, during 1982 there was also a freeze that resulted in substantial crop damage. Unfortunately, it was not possible to distinguish the effects of the freeze from the effects of the drought.

The EPP was reviewed to assess its suitability for estimating the NED effects of the LORS alternatives on agricultural water supply. All five developmental elements illustrated in Figure 2-1 were examined. First, available AFSIRS documents were reviewed to determine its purpose, function, assumptions, strengths, and shortcomings (Thompson and Lynne, 1991). Second, a copy of the modified AFSIRS program for drought impact analysis was obtained from the SFWMD, including input data files, a copy of the computer code, and supporting documentation. Test runs of the modified program were made to evaluate program inputs, function, and outputs. Third, the documentation of the regression analyses that were conducted to develop the functional relationships between simulated ET_{act} and PET, precipitation, and irrigation was reviewed. In addition, SFWMD personnel (Dr. Richard March) involved in developing the EPP were interviewed. Fourth, the spreadsheet prototype of the EPP was examined and tested to evaluate the logic underlying the calculation of the monetary effects of agricultural water shortages. Finally, the draft documentation for the SFWMM was reviewed to determine: (1) the outputs from the model used by the EPP and (2) the function of the AFSIRS module within the SFWMM. In addition, the output files from the EPP runs conducted for this investigation were scrutinized to determine how the EPP interacts with the SFWMM.

Based upon the review of the EPP-related materials, the EPP seems to be a logical and practical approach to a difficult problem (i.e. estimating changes in crop yields and revenues associated with irrigation water shortages). However, there are four categories of issues that qualify the use of the EPP. These issues do not preclude using the EPP to estimate the NED effects of the regulation schedule alternatives on agricultural water supply, but they qualify interpretation of its outputs.

2.5.1 Crop Response

The agricultural science that underlies the AFSIRS model is in its infancy. However, the program has been tested by the SFWMD, and calibrated for use in the SFWMM. The Beta coefficients used in the Stewart equation are less evolved and should be considered experimental at this time. Additional research is needed to refine these coefficients. This research could determine the sensitivity of crop yields and revenue effects to changes in Beta coefficients. The most useful validation of the drought model would be to test it against empirical data from an actual drought event.

It is unclear whether the yield reductions predicted by the modified AFSIRS model imply crop mortality or, in the case of perennials (e.g., citrus), long-term damage that may affect future crop yields. Crop mortality would probably be limited to severe water shortages, but these events may comprise a significant share of potential revenue effects of water shortages. However, as noted previously, the SFWMD has a policy that commits Lake Okeechobee water supplies sufficient to meet at least one-third of the supplemental irrigation needs of EAA farmers. This minimum irrigation level may prevent extensive crop mortality in the EAA during droughts.

2.5.2 Growing Season

The timing of agricultural water supply shortages during the growing season is a critical factor in determining the extent and severity of potential crop losses. The difficulty of applying specific Beta coefficients to particular growth stages was mentioned earlier. In the EPP, the user specifies the start and end months for the growing season for each crop. The simulation of revenue effects is based upon estimates of yield reductions that would result from water shortages during the specified months. If the actual growing seasons are not well aligned with the modeled growing seasons, the accuracy of the simulation could be compromised. The climate of south Florida is problematic in this regard, since it allows more flexibility in planting and harvesting than more northern climates.

There is an additional complication associated with crop rotation. As described previously, it has been estimated that approximately 12.5 percent of the land under sugarcane cultivation is fallow at any given time. If this is true, that would remove over 60,000 acres of sugarcane cultivation from vulnerability to water shortages. The EPP does not take crop rotation into consideration and therefore may overestimate the potential damages associated with water shortages. Land rotation considerations might also be important for other crops, as well.

2.5.3 South Florida Water Management Model Constraints

The SFWMM provides tremendous analytical power for evaluating the regulation schedule alternatives. However, there are some model-related constraints that affect its use in estimating the economic effects of agricultural water shortages. First, the land use categories in the

SFWMM are broader than those used by the EPP. The AFSIRS program is able to accommodate many different crop types and soil varieties not modeled in the SFWMM.

Second, the spatial resolution of the SFWMM model is too coarse to accurately assess the agricultural impacts of the regulation schedule alternatives with great confidence. For example, the SFWMM does not recognize crops other than sugar in the EAA, since none of the four square-mile grid cells are dominated by non-sugar crops. In actuality, there are 40,000 acres of non-sugar crops in the EAA.

In addition, the model presents a single value for soil depth in a grid cell. In the EAA, the depth of the soil is a critical factor in assessing the drought vulnerability of sugarcane. A single value (i.e., model node) for an area of four square miles may mask significant differences in drought vulnerability for the same crop. Finally, the model must make assumptions about the behavior of farmers in the LOSA during extended dry periods. The ability of farmers to borrow water early in the dry season creates significant uncertainty regarding the timing and effects of water shortages.

2.5.4 Prolonged Water Shortages

The EPP calculates crop yield effects on a monthly basis. For shortages of several months duration, the EPP may overestimate the effects on crop yield and revenue because each month is treated independently in the EPP. An example may best explain how an overestimate may occur. If there was a water shortage of 20 percent during the first month of the shortage, crop yields might be reduced by ten percent. If the same shortage persisted to the following month, the crop yield effects would again be calculated at ten percent. At the end of the year, the shortage would be tallied by the model as reducing crop yields by 20 percent. However, a 20 percent shortage sustained over two months might actually result in less than a 20 percent reduction in annual yield. Even if the ten percent value for the second month was correct, it should probably be discounted (i.e., applied to the 90 percent of yield remaining after the first month of the shortage). One possible way to address this issue would be to treat shortages with durations of multiple months as a single event, evaluating the aggregate water shortage and applying that percentage to the maximum crop yield.

2.6 POTENTIAL NATIONAL ECONOMIC DEVELOPMENT EFFECTS ON AGRICULTURAL WATER SUPPLY

The NED account should reflect changes in net farm income that are associated with reduced agricultural water supply. According to the SFWMM analyses, the alternative regulation schedules will have different effects on agricultural water supply in the study area and thereby have different impacts on farm incomes. For the LORSS, the determination of NED effects on agricultural water supply requires a four-part process. First, the available water supplies are estimated for each alternative plan. Second, the supplies of the alternative plans are compared to water demand forecasts to identify potential shortfalls in water deliveries. Third, identified shortages are translated into dollar-value reductions in net farm income. Finally, the monetary costs of water supply shortages of each alternative plan are compared to the costs anticipated in the absence of any action (i.e., comparing the with- and without-project conditions) to estimate the net economic effects of the alternative plans. The first two steps have been accomplished in

the SFWMM using the model's 36-years of daily simulations. The third and fourth steps are addressed below.

2.6.1 Revenue And Income Effects

The economic effects of changes in agricultural water supply can be registered in the NED account if there are resulting changes in either crop damages or land use. No land use effects are anticipated for the Restudy, since implementation of any of the alternative restoration plans is not expected to induce any changes in crop patterns. Therefore, the potential NED effects of changes in agricultural water supply are estimated based upon expected changes in net farm income during drought conditions. The NED account should include the net farm income effects associated with changes in both revenues and production costs resulting from plan implementation.

For sugarcane and non-sugar crops, the cost of crop inputs incurred over the course of the growing season would not change during shortages. The potential income effects of water shortages would therefore be derived from changes in harvesting and transportation (to processing facilities) costs. For sugarcane, harvesting and transportation in the EAA are conducted by the sugar mills, which then deduct these costs from their payments to the farmers for the cane. Sugarcane harvesting costs would not be expected to change during shortages for two reasons. First, while shortages would reduce sugarcane yields, it is assumed that the SFWMD will provide sufficient irrigation water supplies to avoid crop mortality. As a result, the same area would be harvested during shortages as during non-shortage periods, since sugarcane is drought-tolerant. Second, since sugarcane harvesting is entirely mechanized, the combines would harvest the same areas during shortages with costs identical to non-shortage periods.

Under water stress, sugarcane yields in terms of biomass are reduced. Consequently, reductions in transportation costs to the sugar mills are expected. Given the relatively small shortage-induced changes in transportation costs anticipated for sugarcane and the inherent difficulty in quantifying them, it can be assumed for practical purposes that changes in farm revenues are approximately equal to changes in farm income. However, the exclusion of changes in sugarcane transportation costs during shortages may slightly exaggerate reductions in farm income associated with water shortages.

For vegetables and other non-sugar crops in the EAA, the assumption that changes in revenue equal changes in income is valid for other reasons. In the EAA, non-sugar crops such as rice, sod, and truck vegetables are raised by sugar farmers as supplemental crops. Based upon interviews with experts on EAA farm practices, it appears that during shortages, these crops would have irrigation priority over sugarcane. These crops are high-value relative to cane, and they are much more vulnerable to water shortages.

In the LEC, the assumption that changes in revenues would equal changes in income would not be applicable to non-sugar crops (i.e., row crops and citrus). There would be some reductions in harvesting costs, as well as reductions in transportation costs. However, most of the effects of agricultural water shortages in the LEC are associated with urban landscaping and golf land uses, not commercial agriculture. Consequently, the assumption that changes in revenues equal changes in farm income remains valid for agriculture in the LEC, as well as in the EAA.

2.6.2 Agricultural Water Supply in the Everglades Agriculture Area and Lower East Coast

Table 2-5 contains the SFWMM-simulated revenue (and income) effects on agriculture in the EAA and LEC associated with the current regulation schedule and the five alternative schedules. The values contained in this table represent the values of unmet demand for agricultural water supply, translated into income losses using the EPP. The value of unmet demand is defined as the difference between maximum possible yields under unconstrained water conditions and the yields predicted by the model for each regulation schedule. Therefore, the higher the value of unmet listed in the table, the greater the reduction in potential yields (and revenue losses) imposed by each alternative. Alternative regulation schedules with lower unmet demands than existing conditions indicated decreased crop losses (i.e., improved conditions).

The values in Table 2-5 represent simulated income losses from agricultural water supply shortages during the 36-year simulation period. The value includes the estimated demands not met for urban (turf) and golf (turf) land uses, as well as agricultural crops. The average annual values are arithmetic averages of total income effects distributed over the 36 years. As indicated in this table, two of the alternative regulation schedules (Alternative T2 and T3) result in the greatest unmet demand for agricultural water beyond that of the current schedule. The other three alternatives (1bs2, 1bs2_m and T1) are expected to meet agricultural water demands more effectively. The value of the affected crop yields is represented in 2006 normalized prices, as per Corps regulations.

TABLE 2-5
VALUE OF UNMET DEMAND FOR AGRICULTURAL WATER SUPPLY
EAA AND LEC (\$2006)*

Scenario	Area	Total 2000	Average Annual 2000
2007LORS	EAA	\$2,573,060	\$71,474
2007LORS	SA1	\$0	\$0
2007LORS	SA2	\$0	\$0
2007LORS	SA3	\$0	\$0
2007LORS	SA4	\$0	\$0
2007LORS	Total	\$2,573,060	\$71,474
1bs2	EAA	\$3,690,324	\$102,509
1bs2	SA1	\$0	\$0
1bs2	SA2	\$0	\$0
1bs2	SA3	\$0	\$0
1bs2	SA4	\$0	\$0
1bs2	Total	\$3,690,324	\$102,509
1bs2_m	EAA	\$3,815,519	\$105,987
1bs2_m	SA1	\$0	\$0
1b22_m	SA2	\$0	\$0
1bs2_m	SA3	\$0	\$0
1bs2_m	SA4	\$0	\$0
1bs2_m	Total	\$3,815,519	\$105,987
T1	EAA	\$3,714,756	\$103,188
T1	SA1	\$0	\$0
T1	SA2	\$0	\$0
T1	SA3	\$0	\$0
T1	SA4	\$0	\$0
T1	Total	\$3,714,756	\$103,188
T2	EAA	\$5,323,139	\$147,887
T2	SA1	\$0	\$0
T2	SA2	\$0	\$0
T2	SA3	\$0	\$0
T2	SA4	\$0	\$0
T2	Total	\$5,323,139	\$147,887
T3	EAA	\$5,165,974	\$144,949
T3	SA1	\$0	\$0
T3	SA2	\$0	\$0
T3	SA3	\$0	\$0
T3	SA4	\$0	\$0
T3	Total	\$5,165,974	\$143,499

**(totals were generated by the South Florida Water Management Model economic post processor, normalized to 2006 prices, and then given an average annual value between the model analysis period of 36 years)*

3. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

OVERVIEW

The hydrologic effects of the alternative regulation schedules also have implications for M&I water supply. In the LORSS area, most of the M&I water use is in the three service areas of the LEC. If water demands exceed supplies, shortages may result, and cutbacks may be imposed by the SFWMD.

As outlined in the previous chapter, the SFWMD's Water Shortage Plan curtails water use in south Florida using a four-phase progression of increasingly severe restrictions: Phase I (Moderate), Phase II (Severe), Phase III (Extreme), and Phase IV (Critical). Cutbacks in the first two phases are primarily voluntary. In the more severe shortages (Phases III and IV), mandatory use restrictions are imposed. The cutbacks imposed by the plan affect residential, commercial, and industrial water users. The restrictions on M&I water use during shortages have associated opportunity costs. The economic impacts of the alternative regulation schedules are the differences between the without-project costs associated with the current regulation schedule and the with-project costs associated with the alternative regulation schedules.

Whether voluntary or mandatory, shortages of M&I water supply (i.e., agricultural shortages) can have significant economic implications. There may be direct costs associated with active conservation measures (i.e., reducing water use during shortages), particularly for residential and commercial water users who may experience opportunity costs as a result of reduced supplies, affecting water-related activities such as watering lawns and washing cars. If shortages are frequent, there may be M&I costs associated with developing new sources of supply, increased treatment costs, and/or instituting passive water conservation measures (low-flow plumbing fixtures) which reduce day-to-day water use. There may also be secondary effects, such as the utility revenue losses that are experienced when M&I users reduce consumption during shortages.

3.1 CONCEPTUAL APPROACHES TO MUNICIPAL AND INDUSTRIAL WATER SUPPLY EVALUATION

The alternative regulation schedules could potentially affect the frequency, severity, and duration of M&I water shortages. The conceptual basis for evaluating the economic effects of changes in M&I water supply associated with alternative plans is society's willingness to pay (WTP) for the increase in the value of goods and services attributable to the water supplied. The Corps' planning guidance stipulates that where the price of water reflects its marginal cost, the price should be used to calculate WTP for water supply (in this case, for the amount of water foregone in the supply shortfall). In the absence of such direct measures of WTP, the effects of water supply plans should instead be measured by the least cost alternative (LCA) to replace the shortfall in supply.

The LCA method is widely used in the Corps, given the difficulty of directly measuring WTP for water supply. However, for the LORSS, WTP was selected as the primary approach to estimate M&I water supply impacts for two principal reasons. The first reason concerns how M&I water is supplied to users in the LEC. In the LEC service areas, M&I water is supplied to users by

local utilities. The utilities draw upon local water resources (primarily groundwater) to meet customers' needs. When shortages occur during prolonged dry periods, the utilities can draw upon the regional water supply system to augment their supplies or the utilities can develop supplemental sources of water. These supplemental sources include: (1) developing additional well fields, (2) instituting more aggressive water conservation measures, or (3) tapping the deep Floridan aquifer, treating this brackish water with reverse osmosis and blending it with water from other sources.

The ability of local utilities to draw upon the regional system or tap local resources for alternative sources of supply is not a practical alternative. The LCA for a utility during a particular shortage would depend on the condition of the regional system. If the shortage was localized, a utility might be able to draw freely upon the regional system, and supplemental sources of supply would not be needed. However, if the water shortage was regional in nature, then access to regional water supplies would be limited by widespread shortages and institutional restrictions, limiting the ability of local water utilities to develop alternative sources of supply.

The second reason that WTP was selected as the principal approach for calculating the economic effects of M&I water shortages is based on ability of the EPP to estimate M&I water supply effects of the alternative regulation schedules. The SFWMM runs conducted for this investigation compared M&I water supply with demand. This requires a disaggregation/distribution procedure that will account for spatial and sectoral uses, as well as groundwater pumpage. In its 36-year simulations, the SFWMM estimated the location, severity, and duration of M&I water supply shortages. It also simulated the frequency and phase of water shortage declarations based on: (1) Lake Okeechobee levels and (2) salinity intrusion into coastal aquifers (estimated using water surface elevations in monitoring wells). These outputs from the SFWMM were then input to the EPP to calculate the economic effects of changes in the level of M&I water supply for each alternative regulation schedule.

For each of the water shortage phases, the EPP estimates dollar damages from cutbacks based on the WTP (in dollars per 1000 gallons) of regional M&I water consumers. The SFWMD developed these public water supply loss values on the basis of a 1992 survey of M&I water users in south Florida. The survey, which was conducted following regional water shortages in 1989 and 1992, queried respondents' WTP for water under Phase III and Phase IV reductions. SFWMD staff economists adjusted these values to estimate WTP values for Phases I and II and inflated the WTP values for all four water shortage phases to reflect consumer surplus. The water supply shortfalls in a given shortage phase are multiplied by the WTP associated with that phase to determine the economic costs of the shortage. The values of the unmet water demands during M&I shortages are the basis for comparing the alternative regulation schedules against the without-project future conditions.

3.2 EVALUATION OF ALTERNATIVE REGULATION SCHEDULES

The NED costs of reductions in M&I water supply are the changes in the quantity or price of delivered water over time between the with- and without-project conditions. The SFWMM runs indicate that there will be unmet demand for M&I water supply under both existing and future conditions for the current regulation schedule and the alternative regulation schedules. Table 3-2 summarizes the economic value of unmet demand for M&I water supply associated with the

current regulation schedule and the five alternative schedules under the 2000 scenario. As was the case with agricultural water supply, the larger the value, the greater the losses/negative effects associated with water shortages. Alternative regulation schedules with values larger than the without project condition will worsen M&I water supply shortages. Alternatives with lower values than the without project condition represent improvements (i.e., reductions in unmet demand).

Average annual costs are included in this table, which were calculated as the arithmetic average over the 36-year simulation period. The values in Table 3-2 represent the simulated dollar amounts that M&I water users are willing to pay for water they want but do not receive during water shortages.

TABLE 3-2
VALUE OF UNMET DEMAND FOR M&I WATER SUPPLY (2000)
(\$2006)*

Scenario	Area	Total M&I 2000	Average Annual M&I 2000
2007LORS	SA1	\$72,740,000	\$2,020,556
2007LORS	SA2	\$170,484,000	\$4,735,667
2007LORS	SA3	\$133,176,000	\$3,699,333
2007LORS	SA4	\$111,230,000	\$308,972
2007LORS	Total	\$487,630,000	\$10,764,528
1bs2_a	SA1	\$(9,588,000)	\$(266,333)
1bs2_a	SA2	\$(12,293,000)	\$(341,472)
1bs2_a	SA3	\$(17,597,000)	\$(488,806)
1bs2_a	SA4	\$(1,416,000)	\$(39,333)
1bs2_a	Total	\$(40,894,000)	\$(1,135,944)
1bs2_m	SA1	\$(9,588,000)	\$(266,333)
1bs2_m	SA2	\$(12,293,000)	\$(341,472)
1bs2_m	SA3	\$(17,597,000)	\$(488,806)
1bs2_m	SA4	\$(1,416,000)	\$(39,333)
1bs2_m	Total	\$(40,894,000)	\$(1,135,944)
T1	SA1	\$(9,588,000)	\$(266,333)
T1	SA2	\$(12,293,000)	\$(341,472)
T1	SA3	\$(17,597,000)	\$(488,806)
T1	SA4	\$(1,416,000)	\$(39,333)
T1	Total	\$(40,894,000)	\$(1,135,944)
T2	SA1	\$1,915,000	\$53,194
T2	SA2	\$2,292,000	\$63,667
T2	SA3	\$3,469,000	\$96,361
T2	SA4	\$321,000	\$8,917
T2	Total	\$7,997,000	\$222,139
T3	SA1	\$1,915,000	\$53,194
T3	SA2	\$2,292,000	\$63,667
T3	SA3	\$3,469,000	\$96,361
T3	SA4	\$321,000	\$8,917
T3	Total	\$7,997,000	\$222,139

**(totals were generated by the South Florida Water Management Model economic post processor, indexed to 2006 prices, and then given an average annual value between the model analysis period of 36 years. Totals in parenthesis denote that demand has been met and exceeded by the expressed total)*

4. COMMERCIAL NAVIGATION

OVERVIEW

The purpose of this chapter is to evaluate the potential impact of alternative regulation schedules on commercial navigation in the Lake Okeechobee Waterway, which consists of Lake Okeechobee, the Caloosahatchee River, and the St. Lucie canal. The alternative regulation schedules were designed to have different effects on water levels in Lake Okeechobee. The potential impacts on commercial navigation are based on associated changes in the frequency of low water events from the current plan, 2007LORSalternative. If some portion of the commercial vessel fleet draws all of the waterway's authorized depths, reduced lake stages may prohibit passage of those vessels, delay their passage, or induce reductions in their loads. These impacts could have economic impacts on the shippers or the commodities being transported.

As shown in Table 4-1, there are some differences in the frequency of events among the alternative regulation schedules and the 2007LORS schedule. In the 36-years of record simulations, the model estimated that there would be one additional time that the lake stage is below 12 feet for more than 365 days between the 07LORS without-project condition schedule and each alternative. The number of years that the lake stage is below 11 feet for greater than 80 consecutive days over the 36-year simulation resulted in each of the alternative regulation schedules having more of these low-water years. The number of days that lake stage is below 12.56 feet over the 36-year simulation for each alternative is greater than the 07LORS alternative. The assessment of commercial navigation impacts will be based on the differences between the current regulation schedule (07LORS) and each of the four alternative regulation schedules for the three performance measures shown in Table 4-1. Based on these performance measures, ranking the alternatives from least to worst impact on commercial navigation would be as follows: (1) 07LORS; (2) 1bS2-A; (3) T1; (4) 1bS2-m; (5) T3; and (6) T2.

4.1 PHYSICAL FEATURES OF THE WATERWAY

The Lake Okeechobee Waterway was completed in 1937 and includes 154 miles of navigation channel and five lock structures linking Stuart on the Atlantic Ocean with Ft. Myers on the Gulf of Mexico. The five lock and dams (from west to east) are: W.P. Franklin, Ortona, and Moore Haven on the Caloosahatchee River; and Port Mayaca and St. Lucie on the St. Lucie Canal. The Moore Haven and Port Mayaca Locks connect Lake Okeechobee with the Caloosahatchee River and St. Lucie Canal, respectively. Using the locks to designate waterway reaches, the channel dimensions of the Lake Okeechobee Waterway at lake elevation 12.56 ft. NGVD are presented in Table 4-2. As indicated in this table and Figure 4-1, there are two routes from Port Mayaca on Lake Okeechobee's eastern shore to Clewiston on the southwestern shore. Route 1, which cuts across Lake Okeechobee, has an authorized channel depth of eight feet. However, due to one and a half feet of shoaling in the lake just west of Port Mayaca Lock, at the 12.56 feet lake stage navigation depth is now equivalent to six and a half feet. Route 2, which hugs the eastern shoreline, is known as the rim canal. This route has a shallower authorized channel of six feet and is longer than Route 1, but it is more sheltered. However, due to the one and a half feet of shoaling, at the 12.56 feet lake stage, the navigation depth is now equivalent to four and a half feet. The shallow depths of Lake Okeechobee can induce severe wave conditions on the lake

that are disproportionate to wind velocities. During inclement weather, the rim canal is the preferred route between Clewiston and Port Mayaca.

TABLE 4-1
COMMERCIAL NAVIGATION
SIMULATED NUMBER OF UNDESIRABLE LOW LAKE STAGE EVENTS

	07LORS	Alt 1bS2-A	Alt 1bS2-m	T1	T2	T3
Number of times lake stage below 12 feet for more than 365 days	1	2	2	2	2	2
Number of times lake stage below 11 feet over 80 days	5	6	7	8	6	6
Number of days lake stage < 12.56'	2,876	4,839	4,922	4,909	5,156	5,128

TABLE 4-2
CHANNEL DIMENSIONS LAKE OKEECHOBEE WATERWAY

Waterway Reach	Channel Dimensions	Length of Reach
Atlantic Intracoastal to St. Lucie Lock	outside project limits	15.1 miles
St. Lucie Lock to Port Mayaca Lock	8' x 100'	23.7 miles
Port Mayaca Lock to Clewiston (rim canal)	6' x 100'	39.5 miles
Port Mayaca Lock to Clewiston (open lake)	8' x 100'	28.5 miles
Clewiston to Moore Haven Lock (rim canal)	8' x 80'	10.5 miles
Moore Haven Lock to Ortona Lock	8' x 90'	15.5 miles
Ortona Lock to W.P. Franklin Lock	8' x 90'	27.9 miles
W.P. Franklin to Gulf Intracoastal	outside project limits	33.2 miles
TOTAL		154.4 miles (open lake) 165.4 miles (rim canal)

The depth of this waterway is controlled by managing lake levels; no maintenance dredging is conducted for this waterway. Consequently, lake levels above (or below) 12.56 ft. NGVD will result in a corresponding increase (or decrease) in channel depths. Navigation depths are computed by subtracting 12.56 feet from the lake elevation and then adding six and a half feet for Route 1 and four and a half feet for Route 2. For example, at a lake level of 11 ft. NGVD the channel depth would be 4.94 ft. NGVD (11.00-12.56+6.50) in the open lake and 2.94 ft. NGVD (11.00-12.56+4.50) in the rim canal.

There are five locks on the Lake Okeechobee Waterway, all operated by the Corps. Three locks are located on the Caloosahatchee River: the Moore Haven Lock on Lake Okeechobee (R.M.

78), the W.P. Franklin Lock and Dam (R.M. 122) between Tice and La Belle, and the Ortona Lock (R.M. 93.6). In addition, there are two locks on the St. Lucie Canal: the Port Mayaca Lock on Lake Okeechobee's eastern shore (R.M. 38.5) and the St. Lucie Lock (R.M. 15.3) near Interstate 95 (I-95).

Table 4-3 presents the lock dimensions for the five locks and dams on the Lake Okeechobee Waterway. The elevation of the bottom of Lake Okeechobee is approximately equal to sea level. As a result, with a lake elevation at 15.5 ft. NGVD, the Caloosahatchee and St. Lucie locks would have a combined lift of approximately 15.5 feet and 14.5 feet, respectively. The difference is explained by the Caloosahatchee locks releasing further inland (upstream) from the coast than the St. Lucie locks. Three of the locks have head differences of several feet. However, two locks have significantly larger head differences. Ortona Lock has a head difference of approximately eight feet, and St. Lucie typically has lift elevations in excess of 13 feet. The chamber depths of the five locks depend on the lock head. At the lowest operational levels, the chambers would have depths far in excess of the authorized project depths. Therefore, the lock chambers do not constitute depth constraints to waterway traffic under conceivable circumstances.

**TABLE 4-3
LOCK DIMENSIONS
LAKE OKEECHOBEE WATERWAY**

Lock	Dimensions (feet)
St. Lucie	50' x 250'
Port Mayaca	56' x 400'
Moore Haven	50' x 250'
Ortona	50' x 250'
W.P. Franklin	56' x 400'

4.2 WATERWAY OPERATION

As previously discussed, the Caloosahatchee River and the St. Lucie Canal are primary outlets for Lake Okeechobee and critical components of the Lake Okeechobee Waterway. The locks and dams are operated in a manner that supports commercial navigation as well as other project objectives. Each of the locks and dams has a spillway that can be used for the lake's regulatory releases. The spillways and the locks release freshwater downstream and eventually into the Gulf of Mexico and the Atlantic Ocean. Releases are carefully controlled to regulate lake levels, maintain adequate depths for navigation in the two outlet waterways, and minimize salinity impacts on the two receiving estuaries.

Water is typically released through the Caloosahatchee River before the St. Lucie Canal for two reasons. First, freshwater releases to the St. Lucie Canal are limited due to ecological effects of freshwater releases on the estuary. Second, the water treatment facility for the town of Olga is located in the Caloosahatchee reach between the W.P. Franklin and Ortona Locks. The plant is not allowed to discharge chloride-treated effluent to the river if chloride concentrations in the receiving waters are in excess of 250 parts per million (ppm). The three Caloosahatchee locks

and dams are typically operated to keep salinity in this river reach low enough to receive the plant effluent. Since the Caloosahatchee River downstream of W.P. Franklin is tidal, this involves a continual release of freshwater from Lake Okeechobee. In addition, the lock operators will occasionally flush the waterway to remove algae and to restore dissolved oxygen levels. In the St. Lucie Canal, the St. Lucie Lock is the main interface between Lake Okeechobee and the Atlantic Ocean. When the lake level is below 14 ft. NGVD, the Port Mayaca Lock is opened, and water levels for the reach from Lake Okeechobee to the St. Lucie lock are controlled by lake levels.

During water shortages, the operation of the Lake Okeechobee Waterway is altered. In all four phases of the SFWMD's Water Shortage Plan, lock operations can be restricted to conserve water in Lake Okeechobee and maintain acceptable salinity concentrations in the estuaries downstream of the locks. The operation of the W.P. Franklin Lock is a particular focus of the plan. Under the Plan, the SFWMD will request the Corps to limit lockages at W.P. Franklin to one every four hours, once a week, if chloride concentrations at the lock exceed 180 ppm and a rainfall event in excess of one inch in 24 hours is not predicted in the surface water use basin within the next 48 hours. If these restrictions are insufficient to reach the salinity target at W.P. Franklin, the SFWMD can then request the Corps to restrict lockages to one every four hours, twice per week. If these additional measures are insufficient in maintaining chloride concentrations to acceptable levels, the SFWMD can request that the Corps further prohibit lockages.

4.3 COMMERCIAL WATERWAY USE

Table 4-4 provides a summary of the net short tons of freight traffic traversing the Lake Okeechobee Waterway from 1986 through 2004. Commercial navigation on this waterway was relatively stable from 1987 through 2000 with substantial variability year to year. However, there has been a serious decline in freight traffic (net short tons) since 2001. As shown in Table 4-4, the Lake Okeechobee Waterway was used to transport 728,000 net short tons with 2,445 trips in 2000 and only 384,000 net short tons with 2,157 trips in 2001. In 2001, commercial net short tons dropped by 47 percent, but the number of commercial trips only decreased by 12 percent. At the same time, there was a dramatic decrease in the total number of vessels going through the locks from 2000 (52,174) to 2001 (25,036) (these numbers include recreation vessels). From 2001 to 2002, the number of trips as well as the net short tons dropped drastically from 2,157 to 254 trips and 384,000 to 36,446 net short tons. These low numbers continued through 2004 with 142 trips and 332 net short tons of freight. The Jacksonville Lock and Dam Supervisor, Mark Abshire, estimates that over 99 percent of the commercial traffic only uses either W.P. Franklin Lock or St. Lucie Lock or traverse the waterway without using any locks. Therefore, when lock restrictions occurred during the drought of record in 2001, the delays did not deter the commercial activity whereas recreational navigation and the estimated less than one percent of commercial traffic, like commercial yacht delivery vessels and commercial fishing boats, that cross Lake Okeechobee and use more than one lock were negatively impacted.

TABLE 4-4
FREIGHT TRAFFIC, 1986-2004
LAKE OKEECHOBEE WATERWAY

Year	Net Short Tons
1986	1,320,000
1987	676,000
1988	696,000
1989	680,000
1990	665,000
1991	718,000
1992	753,000
1993	832,000
1994	662,000
1995	430,000
1996	409,000
1997	560,000
1998	893,000
1999	850,000
2000	728,000
2001	384,000
2002	36,000
2003	12,000
2004	332

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 2006.

Table 4-5, which contains statistics from Waterborne Commerce of the United States, indicates that petroleum products comprised the overwhelming majority of tonnage shipped in years past. Petroleum products included distillate fuel oil, residual fuel oil, and liquid natural gas. Fuel oil shipments averaged approximately 600,000 tons from 1987-2000 peaking in 1998 at 847,000 tons. All shipments were delivered to the Fort Myers oil-fired electrical generating plant. On an annual basis, fuel oil deliveries from Charlotte Harbor, Florida to Florida Power and Light Company's plant at Fort Myers have accounted for 88 to 99 percent of all commercial waterborne commerce from 1987-2000. These shipments did not pass through any of the Corps locks on the Okeechobee Waterway. Florida Power and Light Company's Fort Myers power plant completed a re-powering in 2002. Re-powering at this plant involves the conversion from oil-fired boiler technology to natural gas-fired, combined-cycle technology. Pipelines of the Florida Gas Transmission Company supply the natural gas. As a result, in 2004, there were no petroleum products transported on the Caloosahatchee. This explains the majority of the drastic decline in net short tons from 2001 to 2002 through 2004.

TABLE 4-5
FREIGHT TRAFFIC, 2000-2004
LAKE OKEECHOBEE WATERWAY
TOTAL TRIPS AND NET SHORT TONS BY COMMODITY

Commodity	2000	2001	2002	2003	2004
Total Trips	2,445	2,157	254	221	142
All Commodities	728,000	384,000	36,446	12,451	332
Petroleum Products	706,000	379,000	32,780	12,423	0
Primary Manufactured Goods	14,000	2,000	2,990	0	300
Crude Materials	2,000	1,000	0	0	0
Manufactured Equipment, Machinery & Products	5,000	2,000	676	28	32
Ton-Miles (000's)	16,197	9,703	3,272	501	46

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 2004.

The lock operators maintain records of the lock operations, including the general characteristics of vessels passing through the locks. These data are compiled in a national database, the Lock Performance Monitoring System (LPMS). This database is maintained by the Navigation Data Center at the Corps of Engineers Water Resources Support Center in Washington, D.C.

Data from the LPMS includes characteristics of the commerce vessels used on the waterway. Table 4-6 summarizes the LPMS vessel profiles for the Lake Okeechobee Waterway locks for 2001. The lock data contains information about recreational boats passing through the locks, as well as commercial traffic.

The number of commercial vessels passing through the locks in 2001 range from 31 to 219 for Ortona and the St. Lucie locks, respectively. The average number of barges per tow is small, ranging from 1.0 to 2.2 for St. Lucie and Moore Haven Locks, respectively. The relatively light volume of traffic and the small tow sizes explain the minimal delays at the waterway locks.

Additional data on the commercial vessels using the Lake Okeechobee Waterway is provided in Table 4-7, which presents Florida state vessel registrations for the counties surrounding Lake Okeechobee. This table includes commercial and recreational vessels by length class. The vessels in this table are primarily small, recreational craft. However, there are larger commercial vessels as well. There is a small but viable fleet of day/dinner cruise vessels that operate during the tourist season from Pahokee, on the eastern shore of Lake Okeechobee, and from Ft. Myers. These vessels have relatively shallow drafts, in the range of four to five feet. The smaller commercial craft may be fishing boats associated with marinas or fish camps on Lake Okeechobee. These operations rent fishing boats and offer guide services as well. The vessel registration information in Table 4-7 must be interpreted with caution for two reasons. First, Palm Beach and Martin Counties are coastal counties with potential vessel registrations for the Lake Okeechobee Waterway and the Atlantic Ocean. Second, the county of registration may not necessarily be the same as the county of operation.

TABLE 4-6
VESSEL PROFILES
LAKE OKEECHOBEE WATERWAY LOCKAGES
JANUARY-DECEMBER 2001

	Vessels				Barges			Total	Tons (000)
	Total	Recreation	Tows	Other	Total	Loaded	Empty		
St. Lucie									
Upbound	2387	2265	107	15	108	59	49	2495	7
Downbound	1904	1780	112	12	114	82	32	2018	13
Total	4291	4045	219	27	222	141	81	4513	20
Port Mayaca									
Upbound	2857	2816	17	24	23	13	10	2880	2
Downbound	2348	2314	17	17	20	12	8	2368	2
Total	5205	5130	34	41	43	25	18	5248	4
Moore Haven									
Upbound	2270	2216	19	35	42	32	10	2312	3
Downbound	2669	2618	19	32	40	34	6	2709	4
Total	4939	4834	38	67	82	66	16	5021	7
Ortona									
Upbound	1877	1848	12	17	20	17	3	1897	2
Downbound	2288	2251	19	18	23	18	5	2311	3
Total	4165	4099	31	35	43	35	8	4208	5
W.P. Franklin									
Upbound	3014	2993	17	4	21	11	10	3035	1
Downbound	3424	3398	17	9	22	16	6	3446	2
Total	6438	6391	34	13	43	27	16	6481	4
Total	25,038	24,499	356	183	433	294	139	25,471	

Source: U.S. Army Corps of Engineers, Lock Performance Monitoring System, 2001.

TABLE 4-7
VESSEL REGISTRATIONS
LAKE OKEECHOBEE COUNTIES
2005

Class	Length	Type	Glades	Hendry	Martin	Okeechobee	Palm Beach	Total	
Class A-1	<12'	Pleasure	106	445	2,223	430	8,752	11,569	
		Commercial	6	6	11	11	76	110	
Class A-2	12'-15'11"	Pleasure	389	752	2,277	1,433	6,009	10,860	
		Commercial	31	26	67	73	169	366	
Class 1	16'-25'11"	Pleasure	903	1,475	9,126	3,853	21,660	37,017	
		Commercial	35	72	297	96	514	1,014	
Class 2	26'-39'11"	Pleasure	30	267	2,547	119	5,962	8,925	
		Commercial	1	22	109	6	213	351	
Class 3	40'-64'11"	Pleasure	16	78	457	9	1,128	1,688	
		Commercial	0	4	43	0	80	127	
Class 4	65'-109'11"	Pleasure	0	0	28	1	102	131	
		Commercial	0	0	5	0	15	20	
Class 5	>110'	Pleasure	0	0	1	0	5	6	
		Commercial	0	0	0	0	0	0	
Canoes		Pleasure	10	19	96	18	245	388	
		Commercial	0	0	0	0	2	2	
Sub-total		Pleasure	1,438	3,036	16,755	5,863	43,863	70,971	
Sub-total		Commercial	73	130	532	186	1,069	1,990	
TOTAL			1,511	3,166	17,287	6,049	44,932	72,961	

Source: Bureau of Vessel Titles and Registrations, Florida Department of Highway Safety and Motor Vehicle. 2005.

4.4 EVALUATION OF ALTERNATIVE REGULATION SCHEDULES

The economic effects on commercial navigation are the changes in the value of resources required to transport commodities and the increase in the value of output from these goods and services. Changes in transportation costs may stem from changes in: (1) the vessel fleet used on the waterways, (2) efficiency in the use of existing vessels, (3) transit time, (4) origin-destination patterns, (5) cargo handling, (6) tug assistance, and (7) use of waterborne transportation, rather than competing modes. The NED effects include the costs of resources, impacts on net income, and operating costs.

The statistics on waterborne commerce and vessels on the Lake Okeechobee Waterway were complemented by extensive field research in the December 1998 LORSS economic evaluation. This research included interviews with: (1) lockmasters of each lock, (2) waterway users, (3) waterway interest groups, and (4) Corps operations personnel involved with the Lake Okeechobee Waterway project. These interviews solicited opinions regarding the potential navigation impacts from changes in the LORS. In addition, the waterway was traversed as part of this field research to identify the sensitivity of commercial navigation to changes in lake levels. This included taking spot soundings to assess channel conditions and evaluating aids to

navigation. Follow-up telephone conversations were conducted for this economic evaluation. The findings are highlighted below.

4.4.1 Commercial Traffic

Based on information from the lockmasters, there are no commercial shipping lines that regularly pass through the Lake Okeechobee Waterway. As a result, there is no fleet of regular commercial waterway users, and there is no regular routing of commodity shipments through the waterway. The commercial traffic consists of special barge shipments that are taking advantage of the shortcut across the peninsula, which can save three and one half days of travel. In some cases, deep-draft tugs transfer the tows to shallow-draft tugs for passage through the Lake Okeechobee Waterway.

In the absence of an established fleet of vessels using the waterway, the analysis of commercial navigation must depend on records of the ad hoc shipments collected as part of the waterborne commerce statistics and the LPMS. It was beyond the scope of this investigation to collect primary data by identifying and interviewing shippers who may use this waterway regarding waterway navigation and their decision making regarding vessels and origin-destination patterns.

The absence of regular vessel traffic through the Lake Okeechobee Waterway combined with the historic profiles of commodities and vessels suggest that commercial navigation on this waterway is and will be at a minimum. With the absence of regular vessel traffic, data is not available to estimate how the fleet of commercial vessels using the waterway might change with the modification of the lake regulation schedule relative to the existing schedule. However, very little change, if any, would be expected, since the differences between the stage-duration curves of the existing condition and new alternatives are relatively small and there is no dedicated fleet.

4.4.2 Groundings

Interviews held with the lockmasters and Corps operations personnel suggested that when lake levels are below 12 ft. NGVD, the frequency of vessel groundings increases. While the problem is most severe for recreational vessels, commercial traffic is subject to groundings, as well. In general, groundings occur when vessels do not stay in the channel. Since most commercial vessels will endeavor to remain in the channel, groundings are less of a problem for commercial vessels than recreational craft. However, at very low lake levels, the authorized channel depths cannot be maintained. Under these circumstances, the Coast Guard will install temporary markers to keep vessels in deep water within the channels. The Coast Guard will also issue a Notice to Mariners warning commercial and recreational navigators about the reduced channel depths.

Of particular concern are two shoal areas that pose hazards to vessels that have drafts close to the authorized channel depth. During average and high lake levels these shoals are not a threat to commercial navigation, but during low lake stages shoals can be problematic. In particular, there is a rock shelf on Route 2 near Port Mayaca Lock and Rocky Reef on Route 1 near Clewiston that are hazardous. At Port Mayaca, the shoal allegedly has only six and one half feet of water at lake level 12.56 ft. NGVD, and the Clewiston entrance allegedly has four and one half feet of water at the same lake level.

As lake levels decline, there is less margin for error. Commercial vessels that stray outside of the channel for any reason can run aground. Rocky Reef on Route 1 near Clewiston is particularly unforgiving of errors. Much of Lake Okeechobee's bottom is soft, but running aground at this location could cause severe damage to vessels. For commercial traffic, it can be particularly challenging to stay in the smaller channel during low lake levels due to the wave and wind action for which Lake Okeechobee is famous. The lower lake levels compound problems with waves since the shallower depths exacerbate wave formation.

If vessels run aground, the Coast Guard at Ft. Pierce is contacted, and a tow from Ft. Meyers is requested. If there is danger to life or property, the Corps project operations office in Clewiston, on the southwestern edge of Lake Okeechobee, will provide assistance. The Corps keeps records of such assistance, but only for two years. As a result, information about groundings on Lake Okeechobee is primarily anecdotal.

4.4.3 Lockage Restrictions During Water Shortages

Although the restriction of lockages as a result of water shortages is uncommon, they may cause delays to some commercial and recreational waterway traffic. Delays are offset to some degree by the opening of the Port Mayaca Lock during low lake levels. However, there are economic effects associated with these delays, particularly for some commercial traffic.

4.5 ASSESSMENT

Based upon hydrologic performance measures, field research and database searches regarding commercial navigation on the Lake Okeechobee Waterway, it can be concluded that the effects of each alternative regulation schedule would have a minor negative impact on commercial navigation relative to the current schedule. The commercial navigation issues on this waterway are directly or indirectly related to lake levels. The infrequent and irregular nature of navigation on the waterway raises the question of whether some shipments through the waterway could be deferred until lake levels increase, with little ill effect. In addition, those shippers who use this waterway may already have made adjustments to meet the fluctuations in lake levels.

However, those that depend on the waterway and cannot defer until lake levels increase, and lightening their loads is not an option, but can only adjust by going around the peninsula, will increase their travel cost by an estimated \$27,850 per trip. Travel time using the waterway takes one and one-half days while travel time around the peninsula requires five days.

Fiscal year (FY) 2006 estimated daily operating costs for shallow-draft tugs range from: \$3,000 per day for the 600 horsepower (hp); \$5,000 per day for the 800 hp; and up to \$7,000 per day for the 1,200 hp model. A shallow-draft tug (800 hp) would move the tows in the waterway, and a seagoing tug would move the tows around the peninsula.

An assumption is made that 1,200 hp boats would be required for the outside run and half of the barges used will be covered and the other half would be deck barges. The average cost per barge is \$100 per day.

Using the above information, the additional costs incurred for a shipper to detour around the peninsula rather than use the waterway would be \$27,850 per trip. This represents the difference

between \$7,500 to use the waterway (1.5 days * \$5,000 for 800 HP Tow) and \$35,350 to go around the peninsula (5 days * \$7,000 per day + \$350 additional barge cost).

In order to estimate the additional increase in commercial navigation costs at different lake stages, information about the number of trips that absolutely must go around the peninsula instead of the waterway must be known. This information is not readily available. Therefore, the magnitude of the negative impact is unknown for each alternative relative to 07LORS. However, given that there is no dedicated fleet, that there is a relatively small difference in the stage-duration curve between the existing operating condition and each proposed alternative, and that there has been a very small amount of commercial traffic since 2001, it is concluded that there will be only minor adverse impacts on commercial navigation.

Therefore, the alternatives are ranked based on the number of times that lake stage is below 12 feet for more than 365 days, the number of years over the 36 years of record that lake stage is below 11 feet for greater than 80 days, and the number of days that the lake stage is below 12.56 feet. The ranking from best to worst alternative is as follows: 07LORS; alternative 1bS2-A; alternative T1; alternative 1bS2-m; alternative T3; and alternative T2.

5. RECREATION

OVERVIEW

In this chapter, the potential economic effects of the alternative regulation schedules on recreation are examined. The discussions focus on water-based recreation, specifically recreational boating and sportfishing.

This assessment of recreation impacts of the LORSS alternatives will be limited to recreational activities that occur on Lake Okeechobee and its immediately adjacent waterways and associated landside facilities.

The economic effects of the alternative regulation schedules on recreation are estimated by quantifying the differences in the quantity and quality of recreation activities expected to occur under with- and without-project conditions. Estimating the change in economic value of recreational activities can be approached in three steps: (1) identifying the recreational resources of Lake Okeechobee and its associated waterways, (2) evaluating the quality and quantity of recreation activities under the with- and without-project conditions, and (3) comparing these quantities and qualities to estimate the effects of the alternative regulation schedules.

5.1 RECREATION RESOURCES

Lake Okeechobee is the largest recreational resource in the region. Lake Okeechobee and its associated waterways and shoreline provide a wide variety of water-based recreation activities for local residents and out-of-state visitors, including: fishing, boating, picnicking, sightseeing, camping, swimming, hunting, air boating, and hiking. The western side of Lake Okeechobee is relatively shallow, with an extensive littoral zone, which comprises approximately one-quarter of the lake area. The littoral zone provides critical habitat for the lake's popular sport fishery and attracts thousands of waterfowl, which lure hunters during the fall migration.

Lake Okeechobee is recognized as supporting one of the best recreational fisheries in the nation. The recreational fishery includes individual anglers fishing from boats and the shore, as well as guided sportfishing. The fishery is large and productive due to the extensive littoral zone that provides abundant habitat for juvenile and adult fish.

Profiles of the main recreation sites on the Lake Okeechobee Waterway are presented in Table 5-1. As indicated in this table, there are 39 recreational sites on the waterway and 34 boat-launching sites that provide access to Lake Okeechobee. The ramps were of particular interest in the investigation since ramp access to the lake could be affected by fluctuations in lake levels that result from the implementation of the alternative regulation schedules.

TABLE 5-1
RECREATIONAL FACILITIES, LAKE OKEECHOBEE WATERWAY

	Corps Operated	Campsites	Showers	Drinking Water	Sanitary	Day Use	Launch Ramp	Boat-In Camping	Fishing Pier
1. W.P. Franklin Lock and Dam (North)		•	•	•	•	•	•	•	•
2. W.P. Franklin Lock and Dam (South)		•	•	•		•	•		
3. Alva Access Area		•					•		
4. La Belle Lions Park						•			
5. La Belle Access Area						•	•		
6. Barron Park				•		•			
7. Belle Hatchee Marina				•	•	•	•	•	
8. Port La Belle Marina				•	•	•	•	•	
9. Ortona Lock and Dam (North)		•		•		•	•		•
10. Ortona Lock and Dam (South)		•	•	•	•	•	•		•
11. Moore Haven Lock (East)		•							•
12. Moore Haven Recreational Village			•	•	•	•	•	•	•
13. Sportsman's Village						•	•		
14. Fisheating Creek							•		
15. Harney Pond Canal					•	•	•		•
16. Bare Beach						•	•		
17. Indian Prairie Canal							•		•
18. Okee-Tanti			•	•	•	•	•	•	•
19. C.Scott Driver							•		
20. Okeechobee					•	•	•		•
21. Taylor Creek							•		
22. Nubbin Slough							•		
23. Henry Creek							•		
24. Chancy Bay							•		
25. Port Mayaca Lock and Dam		•				•	•		
26. Canal Point						•	•		
27. Pahokee			•	•	•	•	•	•	•
28. Paul Rardin Park					•		•		
29. Belle Glade			•	•	•	•	•	•	•
30. South Bay							•	•	
31. John Stretch Park					•	•	•		
32. Corps South Florida Operations		•					•		
33. Clewiston Park							•	•	•
34. Liberty Point			•	•	•		•		
35. Alvin Ward					•		•	•	
36. Port Mayaca Wayside Park							•		
37. Indiantown Marina			•	•	•	•	•	•	•
38. St. Lucie Lock and Dam			•	•	•	•	•	•	•
39. Phipps Martin County Park			•	•	•	•	•	•	•

Source: U.S. Army Corps of Engineers. Lake Okeechobee Waterway Recreation Map.

5.2 RECREATION RESOURCE USAGE

Estimates of current usage of Lake Okeechobee's recreation resources are contained in the Operation and Maintenance Business Information Link (OMBIL), a database that contains usage data for all Corps recreation projects. Table 5-2 presents the OMBIL data for FY 2002 to FY 2005. This table contains visitor hours and visits.

**TABLE 5-2
OMBIL DATA
LAKE OKEECHOBEE WATERWAY
FY 2002–FY2005**

	FY 02	FY 03	FY 04	FY 05
Visitor Hours	10,181,403	11,647,421	10,177,780	12,086,174
Visits	1,031,204	1,089,528	1,026,837	1,104,087

Source: U.S. Army Corps of Engineers. OMBIL.

5.3 FUTURE RECREATION DEMAND

Estimates of future recreation demand were found in the Statewide Comprehensive Outdoor Recreation Plan (SCORP): Outdoor Recreation in Florida-2000. The SCORP divides Florida into recreation regions. Region 10, Treasure Coast, includes Lake Okeechobee. The SCORP categories that apply to recreation on the Lake Okeechobee Waterway are: freshwater boat ramp use, freshwater fishing (non-boat), hunting, and nature study. The 2000, 2005 and 2010 estimates for recreation demand (in user occasions) for these categories are presented in Table 5-3. Freshwater fishing was the only activity that showed a shortage in recreational capacity.

**TABLE 5-3
ESTIMATED RECREATION DEMANDS (IN USER OCCASIONS)
2000 THRU 2010**

	2000	2005	2010	% Change (2005-2010)
Boat Ramp	673,510	750,415	826,777	9.7%
Fishing (non-boat)	1,370,307	1,525,279	1,678,705	9.6%
Hunting	7,375	8,095	8,774	8.0%
Nature Study	877,187	969,527	1,058,861	8.8%

Source: Florida Statewide Comprehensive Outdoor Recreation Plan. 2000.

5.4 ESTIMATED VALUE OF RECREATION RESOURCES

The information presented previously on the type, quality, and quantity of recreation resources at Lake Okeechobee can be used to estimate the value of the recreational resource. As specified in Corps guidance (ER 1105-2-100), the value of a project's recreation resources should be measured in terms of WTP. The following methodologies can be used to estimate WTP: the travel cost method (TCM), the contingent valuation method (CVM), and the unit day value (UDV) method. Either the CVM or TCM approaches are typically required for projects, like Lake Okeechobee, that exceed 750,000 visitor days per year. This analysis of economic effects is being conducted to provide information to assist project decision making, but a benefit cost analysis is not required. Therefore, the UDV method was selected as the means to estimate the value of recreation resources at Lake Okeechobee, since the more extensive analyses required by the travel cost and the CVMs are not needed to support project justification. The UDV method relies on informed judgment to estimate the average WTP for recreation experiences of various types and qualities.

The UDV evaluation procedure requires that the analyst select a specific point estimate from within a range agreed upon by Federal water resource agencies to reflect the quality of the recreational experience along the following dimensions:

- Quality and availability of multiple recreation experiences
- Relative scarcity of the specific recreational experience within the region
- Adequate carrying capacity, without deterioration of the resource or experience
- Easy access to the recreation site(s)
- Aesthetic quality of the environment

The points assigned to each dimension are then summed to yield a total quality estimate for the project site under both with- and without-project conditions (maximum score = 100). The total quality points are then correlated to a specific dollar value that is intended to approximate an individual's WTP for a day of recreation experience. The conversion factor from points to dollar value is specified in an Economic Guidance Memorandum published annually by the Corps. The individual valuation of the recreation experience is then multiplied by demand to estimate total recreation value. Value ranges and factors used in evaluating recreation characteristics (provided in ER 1105-2-100) are shown in Table 5-4.

Points for each of the five categories were assigned to general recreation and hunting/fishing based on the documents, data, and field work described above. The point assignments are presented in Table 5-5.

TABLE 5-4
GUIDELINES FOR ASSIGNING POINTS FOR RECREATION FACILITIES

Criteria	Judgement Factors				
Recreation experience	Two general activities	Several general activities	Several general activities; one high quality value activity	Several general activities; more than one high quality value activity	Number of high quality value activities; some general activities
Total Points: 30 Point Value:	0-4	5-10	11-16	17-23	24-30
Availability of opportunity	Several within 1 hour travel time; a few within 30 minutes travel time	Several within 1 hour travel time; none within 30 minutes travel time	One or two within 1 hour travel time; none within 45 minutes travel time	None within 1 hour travel time	None within 2 hours travel time
Total Points: 18 Point Value:	0-3	4-6	7-10	11-14	15-18
Carrying capacity	Minimum facility for development of public health and safety	Basic facility to conduct activities	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Total Points: 14 Point Value:	0-2	3-5	6-8	9-11	12-14
Accessibility	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site; fair access; good roads within site	Good access, good roads to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Total Points: 18 Point Value:	0-3	4-6	7-10	11-14	15-18
Environmental	Low esthetic factors that significantly lower quality	Average esthetic quality; factors exist that lower quality to minor degree	Above average esthetic quality; any limiting factors can be reasonably rectified	High esthetic quality; no factors exist that lower quality	Outstanding esthetic quality; no factors exist that lower quality
Total Points: 20 Point Value:	0-2	3-6	7-10	11-15	16-20

TABLE 5-5
UDV POINT ASSIGNMENTS
LAKE OKEECHOBEE RECREATION RESOURCES

Recreation	Availability	Carrying Capacity	Accessibility	Environmental	Total Points	UDV
Possible Points	30	18	14	18	20	100
Assigned Pts						
Hunting & Fishing	25	14	11	12	16	78
General Recreation	15	10	10	10	15	\$7.38

Current Corps guidance for UDV (Economic Guidance Memorandum 06-3) includes tables to convert recreation point values into dollar-based UDVs. As shown in Table 5-5, the points assigned to hunting/fishing and general recreation for Lake Okeechobee convert to UDVs of \$8.41 and \$7.38, respectively. These values were applied to the FY 2005 visits derived from the OMBIL. The number of visit to Okeechobee Waterway in FY 2005 was 1,104,087. Twenty eight percent of the total visits or 309,144 visits were assigned to hunting and fishing and 72 percent or 794,943 were assigned to general recreation. As a result of this procedure, the total value of recreation at Lake Okeechobee in 2005 was estimated at \$8,466,580, calculated as [(309,144*\$8.41)+(794,943*\$7.38)].

5.5 POTENTIAL EFFECTS OF ALTERNATIVE REGULATION SCHEDULES

The potential effects of the alternative regulation schedules on the quality and quantity of recreation depends on the frequency of change from the current regulation schedule and the sensitivity of existing recreation facilities and activities to these changes. No additional facilities are being contemplated as part of the LORSS project. In the case of the Lake Okeechobee Waterway, the quantity of recreation activities primarily refers to the ability of visitors to access the lake's recreation resources. The quality of recreation activities refers to how much enjoyment or satisfaction those activities produce. Finally, there are recreational safety issues that also may be sensitive to changes in lake levels.

5.5.1 Quantity Of Recreation Participation

Fluctuations in lake levels can affect the quantity of recreation participation on Lake Okeechobee. As an indicator of the sensitivity of recreation to lake levels, lake levels (measured to two decimal places) are posted daily on the front pages in newspapers of lakeside communities, such as the Clewiston News. Low lake stages can affect lake recreation in two principal ways. First, lake levels determine areas of Lake Okeechobee that are accessible to boaters and fishermen. Specifically, access to much of the lake's littoral zone, which occupies approximately 25 percent of the lake area, can be reduced during low lake stages. According to discussions with local boaters, many anglers and boaters will not go out on Lake Okeechobee when lake levels are below 11 ft. NGVD since access to many fishing locations is not possible. However, the difficulties faced by boat anglers during very low lake levels are somewhat offset by increased opportunities for anglers to wade from shore. Second, some of the boat ramps on Lake Okeechobee would be inoperable below 10 ft. NGVD. However, the depths of Lake Okeechobee at these extremely low lake stages would probably curtail boating activity before lake access via the ramps became a problem, particularly on the western side of the lake. The ramps at Corps recreation sites along the waterway typically extend from 9 ft. to 21.5 ft. NGVD. In addition, these specifications are recommended to state and local governments when they construct or rehabilitate boat ramps on the waterway. Discussions with boaters launching from the ramps on this waterway indicated that two feet of water is required at the bottom of the ramp to launch the small (bass) fishing boats that are typically used on Lake Okeechobee.

The spot soundings of boat ramps conducted as part of the 1998 study identified some boat ramps that were sensitive to lake levels. Four ramps have terminus depths below five feet; nine ramps had terminus depths between five and seven and a half feet; and five ramps had depths in excess of seven and a half feet. The lake stage at the time of the soundings was 15.2 ft. NGVD. Therefore, some of the ramps would be inoperable at the lowest lake levels (10 ft. NGVD). This

could potentially inconvenience some ramp users, but they could access the lake via nearby substitute ramps.

5.5.2 Quality Of Recreation Activities

The quality of recreation on the Lake Okeechobee Waterway is also subject to fluctuations in lake levels. Of the various lake-related recreation activities, sportfishing may be the most sensitive to changes in lake levels.

Fluctuations in lake stage have complex effects on fish stocks in Lake Okeechobee. Prior to 1900, Lake Okeechobee was clear with a sandy bottom. Lake stages varied with the season as overflow from the lake fed the southward sheetflow into the Everglades. However, construction of the levee system around Lake Okeechobee eliminated lake overflow and facilitated backpumping of nutrient-rich water from the EAA. In the last 30 years, rising nutrient levels have degraded water quality in Lake Okeechobee, and the lake has become increasingly eutrophic. More than one-half of the lake bottom is now covered with mud. In addition, periodic increases in lake stages (made possible by the levee system) have diminished the habitat quality of the littoral zone.

Under natural conditions, the variations in lake stages supported a diversity of plant communities in the littoral zone, providing high-quality fish and wildlife habitat. A given stage of Lake Okeechobee can have both positive and negative effects on fish and wildlife habitat. On the positive side, low lake stages:

- Allow muck to consolidate on the exposed lakebed thereby improving water quality and benthic habitat;
- Permit emergent vegetation to extend further into the lake, cleansing the water column; and,
- Enable the Florida Fish and Wildlife Conservation Commission (FFWCC) to conduct controlled burning of exotic (i.e., non-native) species such as torpedo grass, hydrilla, and cattails; and allowing native plants to recolonize the area.

On the negative side, low lake stages can:

- Reduce access of fishermen to the lake, and
- Kill desirable aquatic vegetation, such as bullrush and eelgrass (although undesirable exotics are also killed when their habitat is drained).

High lake stages have mixed effects as well. On the positive side, high lake stages are desirable since they kill undesirable exotic vegetation, such as hydrilla. On the negative side, desirable aquatic vegetation is also adversely impacted by high lake stages.

The ecological effects of changes in lake stages must be evaluated from both the short-term and long-term perspectives. For example, recreational fishing may suffer in the short-term when lake stages are low, since the water is warmer and many gamefish are forced from shallow to deep water. However, long-term benefits to fishing from the drawdown can be realized the following year as fish stocks increase due to habitat improvements. Similarly, high lake stages may

increase fishing in the short-term by allowing better access to Lake Okeechobee, but the inundation of the littoral zone may have adverse effects on fishing the following year as a result of its diminished function as a fish nursery.

Among the causal factors for the ecological decline of the littoral zone are excessive fluctuations in lake stage, including the extent and duration of the fluctuations. From an ecological perspective, Lake Okeechobee lake stages are generally higher than desirable during the wet season (June through August) and generally lower than desirable during the dry season (October through March). While some lake stage fluctuations are desirable for purposes of fish and wildlife habitat, the net positive effects begin to erode when the fluctuations inundate or expose the littoral zone to the point of causing short-term and long-term stress on desirable fish and wildlife habitat.

5.5.3 Simulated Effects of Alternatives

Table 5-6 presents the simulated effects of the alternative regulation schedules on Lake Okeechobee stages. The simulated effects for the number of times stage is less than 12 feet for more than one year for each alternative regulation schedule is two while it is one for the current regulation schedule, 07LORS. None of the alternative regulation schedules are an improvement over the 07LORS with respect to these lake stage performance measures. Although the number of days stage is less than 11 feet for greater than 80 days is almost three times greater than the current 07LORS. Alternative 1aS2-B has the least change from 07LORS while Alternative T3 has the greatest change.

TABLE 5-6
SIMULATED EFFECTS OF ALTERNATIVE REGULATION SCHEDULES ON LAKE
OKEECHOBEE STAGES (Less than 11 and 12 feet ngvd)

Stage Measures	07LORS	1bS2-A	1bS2-m	T1	T2	T3
Number of times lake stage < 12 ft. NGVD for > 1 year	1	2	2	2	2	2
Number of times lake stage < 11 ft. NGVD for > 80 days	5	6	7	8	6	6
Number of days lake stage is below 11 ft. NGVD	524	1403	1427	1494	1576	1810

Fishery biologists of the FFWCC and sport fisherman on Lake Okeechobee indicate that low lake levels reduce the quantity and quality of the lake's littoral zone and thereby adversely affect critical spawning habitat. Conversely, high water levels on Lake Okeechobee can also impact the sport fishery by inundating the littoral zone of the lake. Concerns regarding the effects of high water levels in the littoral zone on fish and wildlife (especially bird) habitat was one of the reasons that the LORSS was initiated. Although it is agreed that low lake stages are detrimental to Lake Okeechobee's ecology, the U.S. Fish and Wildlife Service (USF&WS) believes that high

lake stages are far more detrimental to Lake Okeechobee's ecology than the low stages. The alternative regulation schedules were designed to have fewer high lake stages than the current regulation schedule. As shown in Table 5-7, the number of times that lake stage is above 17.25 feet for more than seven consecutive days for each alternative is as follows: 07LORS is 8; alternative 1bS2-A is 1; and alternatives 1bS2-m and T1, are zero. Alternatives T2 and T3 are both 1. The number of times that lake stage is above 17 feet for each alternative is as follows: 07LORS is 11; alternative 1bS2-A is 4; 1bS2-m, T1 and T3 are 2; and alternative T2 is 3.

TABLE 5-7
SIMULATED EFFECTS OF ALTERNATIVE REGULATION SCHEDULES ON LAKE
OKEECHOBEE STAGES (greater than 17 feet ngvd)

Stage Measures	07LORS	1bS2-A	1bS2-m	T1	T2	T3
Number of times lake stage > 17.25' NGVD for > 7 days	8	1	0	0	1	1
Number of times lake stage > 17' NGVD	11	4	2	2	3	2

There is a significant reduction in the number of times lake stages are over 17.25 feet for greater than seven days and greater than 17 feet for between the 07LORS and each alternative, but the change between one alternative and another is relatively small. According to the USF&WS, the positive changes in Lake Okeechobee's ecology from the reduced number of high lake stages outweighs the negative changes in the lake ecology from the increased number of low lake stage.

These high and low water conditions affect fishing either directly or indirectly, but there are also short-term considerations regarding whether the fish are "biting." Local anglers report that the quality of the fishing declines significantly when Lake Okeechobee's levels get low, water temperatures rise, and dissolved oxygen levels fall. Discussions with sport fishermen on Lake Okeechobee yield a variety of opinions regarding the critical threshold when lake levels begin to affect the quality of fishing. In general, this threshold was reported to be approximately 13 ft. NGVD.

The relationship between quality of fishing and lake levels has several qualifying factors. First, low lake levels are important relative to the quality of fishing for particular sportfish at different times of the year. The quality of fishing for particular species varies with the seasons. If low water occurred at a time when the fishing was not particularly good, the effects of the low water on fishing would be less, relative to other times of the year. A second qualifying factor is that low lake levels do not affect the quality of fishing for all sport species. While the quality of bass fishing may suffer as access to the lake's littoral zone is reduced, crappie fishing may be relatively unaffected, since crappie are usually caught in deep water.

5.5.4 Recreational Safety

Recreational hazards on Lake Okeechobee can be exacerbated by lower lake levels. The potential for vessels to run aground increases as lake levels fall. The hazards to recreational navigation are greater than for commercial traffic, since commercial traffic generally follows designated channels, and recreational boaters move freely around Lake Okeechobee. On most occasions, there are no injuries, and the boats are not damaged by the soft bottom of Lake Okeechobee. However, there are occasions where life and property are at risk, especially during inclement weather. Long exposures to large waves can severely damage or destroy grounded vessels, leaving boaters at risk. Based on conversations with Corps operations personnel who are often called upon to assist grounded vessels, groundings in lake levels above 12 ft. NGVD are infrequent, perhaps several groundings per month. However, below 12 ft. NGVD, the frequency of groundings increases substantially, to as many as several groundings per day. The timing of the low lake levels is again a critical factor with respect to this safety issue. During the winter months, when tourist activity is highest, there are a large number of vessels on the lake, many of the operators are relatively inexperienced, and the likelihood of groundings is higher.

Another recreational safety issue that is affected by lake level fluctuations is wave action on Lake Okeechobee. Even at its highest levels, Lake Okeechobee is subject to hazardous wave action, since it is so shallow. According to local boaters, the wave action on Lake Okeechobee substantially increases as lake levels drop, increasing the risk to recreation vessels.

5.6 ASSESSMENT

There are a variety of issues regarding recreational quantity and quality that are sensitive to changes in low and high lake levels. These include access of boaters and anglers to Lake Okeechobee, movement around the lake, the quality of their recreation experience, and their safety while participating in these recreational activities. The quantity and quality of recreation on Lake Okeechobee begins to reduce as lake levels fall below 13 ft. NGVD. Below lake stage 11 feet, many anglers and boaters will not go out on the lake since access to many fishing locations is not possible. Lake Okeechobee would experience low levels under both with- and without-project conditions. The 12.56 feet lake stage is around the range where quantity and quality of recreation on Lake Okeechobee begins to reduce. The percent increase in the numbers of days that lake stage is below 12.56 ft. NGVD may have a minor adverse impact on visitation. When lake stage is below 11 feet, there may be additional, but only minor adverse effects on recreation quantity since the quality of the recreational experience has already been significantly reduced to the point where the majority of boaters and anglers have ceased recreational activities.

As discussed previously in this chapter, the quality and quantity of recreation declines when lake levels fall below 13 ft. NGVD. Therefore, as shown in Table 5-8, the performance measure of the percentage change in number of days of stage events less than 12.56 feet would be a useful indicator of recreation impacts. The performance measure of the percentage change in number of days that stage is greater than 17 feet would be a useful indicator to observe the long-term improvements of Lake Okeechobee's ecology. However, this analysis focuses on the short-term recreation impacts of the alternative regulation schedules. It does not reflect the important role of a healthy littoral zone in maintaining the long-term health of the fishery. Therefore, the negative impacts of an increase in the number of days will be measured in this analysis.

A scenario was constructed to assess the economic sensitivity of recreation to changes in lake levels. As shown in Table 5-8, the performance measure of the percentage change in number of days that stage is less than 12.56 feet was used to determine the economic impacts of each alternative compared to the 07LORS regulation schedule. The additional days below lake stage 12.56 feet were calculated into percentage change over a 36-year period.

TABLE 5-8
SIMULATED EFFECTS OF ALTERNATIVE REGULATION SCHEDULES ON LAKE
OKEECHOBEE STAGES (below 12.56 feet ngvd)

Stage Measures	07LORS	1bS2-A	1bS2-m	T1	T2	T3
Number of days lake stage is below 12.56 ft. NGVD	2876	4839	4922	4909	5156	5128
Increase in days for lake stage below 12.56 ft. Alternative from 07LORS		1963	2046	2033	2280	2252
Percentage Increase for lake stage below 12.56 ft.		68.3%	71.1%	70.7%	79.3%	78.3%
Over 36-years of analysis						

In order to estimate the additional losses in benefits to recreation at different lake stages, information regarding the number of visits that would not occur because of the change in lake stage must be known. This information is not readily available. Therefore, the magnitude of the negative impact of each alternative is unknown.

Since there is no reliable data that shows the change in number of visits when lake stages are below 12.56 feet and since no benefit to cost ratio is required for this economic analysis, it can be determined that the alternative with the least increase in the number of days for lake stage below 12.56 ft. NGVD is the alternative with the least negative impacts to the project. This would be Alternative 1bS2-A since it has a 68.3 percent increase in number of days over the 36-year period of analysis from the 07LORS plan when lake stage is below 12.56 feet. The worst negative impact would be with Alternative T2 with a 79.3 percent increase in number of days from the 07LORS plan when lake stage is below 12.56 feet.

Based on Table 5-8, the ranking of alternatives from best to worst is as follows: 07LORS; Alternative 1bS2-A; Alternative T1; Alternative 1bS2-m; Alternative T3; and Alternative T2.

6. COMMERCIAL FISHING

OVERVIEW

Lake Okeechobee is home to an active commercial fishing industry. This includes several different types of commercial fishing operations and landside support activities, such as marinas and fish houses, which purchase the catch for wholesale and retail distribution. Large scale commercial fishing began in Lake Okeechobee around 1900 with the use of haul seines as primary gear, although trotlines, pound nets, and wire traps were also utilized. Catfish were the most commonly sought species by commercial fishermen. Other species such as bluegill, redear sunfish, and black crappie, as well as largemouth bass and mullet were also taken.

In 1916 the Florida Legislature imposed the first regulation on the industry, including a four-month closed season on haul seines, a maximum haul seine length, and a minimum haul seine mesh. Despite these initial regulatory efforts, commercial catches waned, due in part to over-fishing and in part to man-made changes in Lake Okeechobee. The levee on the southern shore of Lake Okeechobee prevented fish from entering adjacent marshes to spawn. Additionally, the emerging sport fishing industry began to push for increased regulation of the commercial fishing industry, claiming that commercial harvesting of game fish, particularly by haul seining, was detrimental to game fish populations. As a result, commercial fishing became increasingly regulated throughout the 1950s, with stronger restrictions on commercial harvest of game fish and limits on the use of commercial gear.

In 1976, the FFWCC authorized a commercial fishing program with the joint goals of improving lake water quality and restoring the sport fishery. The FFWCC recognized that commercial fish removal was a practical tool to improve the structure of game fish populations, as well as to remove nutrients (nitrogen and phosphorus) from Lake Okeechobee. The commercial harvest and sale of freshwater game fish (except black bass and chain and redfin pickerel) and the use of haul seines and trawls were approved. Initially, 40 haul seine permits and 200 trawl permits were issued. To avoid conflicts with popular sport fishing areas, haul seines and trawls were prohibited from operating within one mile of emergent (shoreline) vegetation.

In 1981, a severe drought resulted in historically low water levels in Lake Okeechobee. The lake's littoral zone was almost entirely drained, forcing fish populations from the shallows into deeper, open water. Widespread concern that the commercial fishing industry would over-harvest the dislocated fish populations led the FFWCC to temporarily suspend the use of haul seines and trawls for the harvest of game fish. In November 1982, the harvest and sale of some game fish (primarily bluegill and redear sunfish) and the operation of ten haul seines were re-authorized. Trawl permits and the commercial harvest and sale of black crappie were not re-authorized.

Except for a 1995 state-wide ban on the commercial harvest of striped mullet, regulation of the commercial fishery has remained unchanged since 1982. Commercial fishing activity is banned on weekends and holidays, but otherwise occurs year round. The three primary gear types utilized on Lake Okeechobee are haul seines, trot lines, and wire traps. Haul seines are used to fish primarily for bream, although the by-catch (i.e., catfish, bullhead, shad and gar) must also be

kept. Most of the current haul seiners operate out of Clewiston, although one operator is located in Pahokee. Daily haul seine harvests are accepted at four local fish markets: Jones Fish Company, Rudd's Fish House, Met's Mouth of the South, or B&R Fish House. Haul seine fishermen are responsible for filing weekly harvest reports with the FFWCC.

Commercial fishermen using trotlines or wire traps on Lake Okeechobee fish primarily for catfish. Gear regulations do not restrict the length of trotlines; however, each line is limited to a maximum of 500 individual hooks. Wire trap designs are restricted to two funnels at one end. Maximum trap dimensions must not exceed seven feet in length or 32 inches in width. Additionally, the minimum mesh size for wire traps is one inch, and all wire traps must be submerged a minimum of five feet. Commercial harvests by trotliners are taken at two fish houses in Okeechobee (Stoke's and Dean's) and one fish house in Pahokee (Jones Fish Company). Jones Fish Company also accepts catch by wire trap. Fishermen using either wire traps or trotlines on Lake Okeechobee must have a State commercial fishing license. Because commercial fishing licenses are not specific to a particular fishery, the number of trotliners and wire trappers on Lake Okeechobee cannot be determined from license data. However, catch by gear type is recorded for Lake Okeechobee through reports that must be filed by each fish house with the FFWCC. Annual commercial fish harvests by species and gear type from 1986 to 1996 are contained in Table 6-1.

As part of the field investigation for this study, interviews with commercial fishermen, fish houses, and the FFWCC were conducted to determine the scope of commercial fishing on Lake Okeechobee and assess its sensitivity to the potential changes in lake levels resulting from the alternative regulation schedules. Several fish houses were interviewed to determine current market prices (wholesale) in order to estimate commercial fishing income. The following average market prices were obtained from the fish houses: catfish (\$.40/lb.), bream (\$.90/lb.), shad (\$.25/lb.), and tilapia (\$.25/lb.). Based upon these prices and the total weight of catches on all gear, the 1996 value of the wholesale commercial fishery for the represented fishes is approximately 2.5 million dollars (as per table 6-1, for all catfishes, bream, shad, and tilapia).

In his 1987 study of the economic effects of commercial fishing on Lake Okeechobee, Bell (1987) estimated that there were a total of 210 jobs associated with commercial fishing in Lake Okeechobee. These included 190 jobs for fishermen using all types of gear and 40 landside jobs in local fish houses.

There is a continuing controversy in the Lake Okeechobee region regarding the compatibility of commercial fishing and sport fishing. Some sport fishermen accuse the commercial fishermen of degrading the sport fishery with excessive harvests. The FFWCC has conducted a variety of studies that suggest commercial fishing actually benefits sport fishing by removing non-sport species and reducing nutrient levels in Lake Okeechobee that these species have absorbed. In general, the sport fishermen are skeptical, but the FFWCC has maintained that the sport fishery has thrived in recent years despite commercial fishing.

TABLE 6-1
COMMERCIAL FISH HARVEST (POUNDS)

LAKE OKEECHOBEE, 1986-1996										Striped	Mullet	Tilapia	Total
		White	Channel	Brown	Yellow	Redear	Shad	Gar	Striped	Mullet	Tilapia		
TROTLINE	Catfish	Catfish	Bullhead	Bullhead	Bluegill	Sunfish							
1986-1987	2,061,860		266,814	34,058	0							2,362,732	
1987-1988	1,993,339	30,896	20,816	1,367								2,046,418	
1988-1989	2,174,885	160,837	27,159	247								2,363,128	
1989-1990	1,666,426	223,882	38,267									1,928,575	
1990-1991	1,495,038	350,641	45,448									1,891,127	
1995-1996	1,504,830	372,966	84,443	2,293								1,964,532	
HAUL SEINES													
1986-1987	202,399	78,527	133	532,361	178,005	588,232	70,788	119,390				1,769,835	
1987-1988	386,633	27,489	1,664	386,498	205,563	499,374	97,485	264,222				1,868,928	
1988-1989	320,384	22,362	9,647	700,300	119,218	361,834	86,803	176,294				1,796,842	
1989-1990	295,981	162,051	72,497	717,250	272,364	521,245	100,766	167,388				2,309,542	
1990-1991	430,064	251,862	25,970	875,319	265,253	409,061	252,407	164,257				2,674,193	
1995-1996	877,047	138,433	107,161	625,329	276,735	1,557,969	295,190		136,308			4,014,172	
WIRE TRAP													
1986-1987	38,751	188,033	33,310									260,094	
1987-1988	208,076	135,536	43,563	85								387,260	
1988-1989	62,182	11,173	17,353	1,792								92,500	
1989-1990	34,700	22,349	6,109	23								63,181	
1990-1991	52,732	7,189	2,094									62,015	
1995-1996	20,467	8,509	4,401									33,376	
ALL GEAR													
1986-1987	2,303,010	533,374	67,501	532,361	178,005	588,232	70,788	119,390				4,392,661	
1987-1988	2,588,048	193,921	66,043	1,452	386,498	205,563	499,374	97,485	264,222			4,302,606	
1988-1989	2,557,451	194,372	54,159	2,039	700,300	119,218	361,834	86,803	176,294			4,252,470	
1989-1990	1,997,107	408,282	116,873	23	717,250	272,364	521,245	100,766	167,388			4,301,298	
1990-1991	1,977,834	609,692	73,512	875,319	265,253	409,061	252,407	164,257				4,627,335	
1995-1996	2,402,343	519,908	196,005	2,293	625,329	276,735	1,557,969	295,190		136,308		6,012,080	

Source: Florida Game and Freshwater Fish Commission.

6.1 POTENTIAL EFFECTS ON COMMERCIAL FISHING IN LAKE OKEECHOBEE

Changes in lake levels associated with the alternative regulation schedules could impact commercial fishing operations and/or the stocks of commercial fish. Fluctuations in lake levels could also potentially affect landside support services. The purpose of this analysis is to determine whether commercial catch or operating costs would be affected by the alternative regulation schedules and, if so, to quantify the NED effects of these changes.

The NED account registers changes in net income from commercial fishing operations. Net income changes result from either changes in the size of the catch (net revenues) and/or changes in the cost of catching the fish (net operating costs). The LORSS alternatives are not anticipated to affect the overall size of the Lake Okeechobee fishery or the amount of the commercial fishing catch. In fact, the single greatest determinant in the size of the fishing catch (and net fishery revenues) is the complex series of operational restrictions placed on the fishery by FFWCC.

The cost of catching fish (net operating costs) could potentially be changed if the LORSS were modified. Interviews with commercial fishermen on Lake Okeechobee were conducted to: (1) evaluate the operations and economics of commercial fishing on the lake and (2) determine the sensitivity of commercial fishing to changes in lake levels associated with the alternative regulation schedules. The interviews with commercial fisherman were conducted with haul seiners. Questions regarding commercial fishing with trotlines and wire traps were answered by representatives of the Okeechobee FFWCC field office, located on the north side of Lake Okeechobee.

The total number of haul seine permits are limited to ten in order to keep fish yields sustainable. The profitability of the haul seine operations are indicated by the long waiting list for permits reported by the FFWCC. Although some of the vessels are larger, most of the haul seine operations use vessels with lengths of approximately 35 feet and drafts of four to five feet, depending on the vessel and the size of the catch in the hold. In general, the seiners prefer low lake levels to high lake levels. The reason is based on their equipment. The seines are set by driving a metal pole into the lake bottom with one end of the seine attached. The fishing boat then motors away laying the seine in a large arc. The boat slowly completes the circle as it returns to the pole. Another pole is driven adjacent (approximately one foot distance) to the first. The net is pulled through the space between the poles, slowly closing it around the enclosed fish. The fishermen report that deeper waters are problematic for haul seines, because deeper waters require larger poles which are more difficult to drive into the lake bottom. Fishermen also indicated that they do not like to fish in deep waters of Lake Okeechobee, since the nets will sink into the muddy bottom. It is possible for haul seines to be used at depths over 20 feet, but some fishermen would need to purchase new nets, and the costs are compounded by the physical challenge of using haul seines in deeper water.

The haul seiners prefer lake levels that are in the 13 to 14 ft. NGVD range. Lower lake levels constrain the haul seiner's movements around the lake. Higher lake levels make haul seiner's gear more difficult to use and induce the fish to move into shallow waters that are inaccessible to commercial fishermen. In addition, the commercial fishermen recognize that very high or very low lake levels inundate or drain the littoral zone which is critical to fish spawning. The higher water temperatures of low water were also cited as adversely impacting spawning.

The haul seiners operate year round. The haul seine licenses require that fishermen fish at least 120 days per year. Fishermen apparently do not fish much more than this due to adverse weather considerations on Lake Okeechobee. If winds are in excess of 15 knots, the fishermen generally will not leave port, since waves on Lake Okeechobee are so problematic. The connection between increased wave formation and lower lake levels was also cited by these fishermen.

Fishermen who use trotlines and wire nets generally prefer high water conditions since these fishermen operate in the deeper waters of Lake Okeechobee to harvest catfish. Bell (1987) estimated that there were approximately 80 trotline fishermen operating on Lake Okeechobee. According to FFWCC representatives, there are only a few fishermen who use wire nets, and these fishermen are required by their fishing licenses to have at least five feet of water overhead. Wire net fishermen generally prefer water depths that are approximately eight feet (which is the authorized channel depth in Lake Okeechobee at lake level 14.56 ft. NGVD).

6.2 ASSESSMENT

In general, commercial fishing on Lake Okeechobee is not very sensitive to changes in lake levels. The operating draft of commercial fishing vessels are sufficiently shallow to allow access to Lake Okeechobee throughout the range of lake levels anticipated with the alternative regulation schedules. While fishermen seem to prefer lake levels in the intermediate range, most would prefer to have lower lake levels to higher lake levels.

In terms of the size of fish stocks, the ecological effects of the alternative regulation schedules could potentially affect the number of fish and mix of species in Lake Okeechobee. The alternative regulation schedules are all expected to improve habitat conditions in Lake Okeechobee's littoral zone by reducing the extent and duration of extreme lake stages relative to the future without-project condition. This would probably translate into an increase in the size of commercial fish stocks. The commercial fishermen interviewed indicated that very high or very low lake levels inundate or drain the littoral zone which is critical to fish spawning. The higher water temperatures during low water periods were also cited as adversely impacting spawning.

Despite the positive ecological effects of the alternative regulation schedules, it is unlikely that the resulting marginal increase in fish stocks will significantly affect the size of the commercial fish catch. The single greatest determinant of the size of the fishing catch (and net fishery revenues) is the complex series of operational restrictions placed on the fishery by FFWCC to promote a sustainable commercial harvest. These regulations are not expected to change between the with- and without-project conditions. It is unlikely that the FFWFC will allow a significant increase in the commercial harvest following implementation of the regulation schedules.

In terms of physical access to the fishery, the operating drafts of commercial fishing vessels on Lake Okeechobee are sufficiently shallow to access commercial stocks throughout the range of lake levels anticipated with the alternative regulation schedules. However, there may be some marginal benefits realized by reducing the costs of fishing operations, since fishermen seem to prefer lake levels in the intermediate range and the alternative regulation schedules are anticipated to moderate lake stage fluctuations.

Regulation of the fishery by the FFWFC appears to be the most significant determinant of both the size of the commercial catch and the net income of commercial fishermen. While the FFWFC has shown (e.g., 1981) that it will modify the fishery restrictions in response to extreme changes in lake levels, it is not anticipated that any similar action would be taken in the foreseeable future. Commercial fishing on Lake Okeechobee currently appears to be at sustainable levels. Therefore it is unlikely that any regulatory changes would be made in response to the modest effects anticipated from implementation of any of the alternative regulation schedules.

7. COMMERCIAL AND RECREATIONAL FISHING IN THE CALOOSAHATCHEE AND ST. LUCIE ESTUARIES

OVERVIEW

The alternative regulation schedules for Lake Okeechobee were formulated to keep lake levels low in the wet season (June to October) to provide flood and hurricane protection; and to keep levels high in the dry season (November to May) for water supply purposes. Lake Okeechobee has four principal outlets for discharging inflows received from its tributary waterways: (1) evaporation, which in the south Florida climate accounts for 70 percent of the lake's water loss, (2) the distributary canals that convey water southward to the LEC and the Everglades, (3) the Atlantic Ocean via the St. Lucie Canal, and (4) the Gulf of Mexico via the Caloosahatchee River. The quantity, quality, and timing of the releases to the St. Lucie and Caloosahatchee estuaries are critical determinants of the diversity and productivity of those ecosystems. The purpose of this chapter is to interpret the economic consequences of the alternative regulation schedules. The potential economic consequences could be manifested through changes in the hydrologic regimes of the outlet waterways and resultant ecological effects on the estuarine ecosystems.

7.1 EFFECTS OF LAKE RELEASES ON ESTUARINE ECOLOGY

These two estuaries are highly productive ecosystems that exist at the interface between freshwater and seawater. The St. Lucie Estuary is a small estuary of approximately 6,000 acres located in Martin and St. Lucie counties. The North and South Forks, which constitute the inner estuary, converge at the City of Stuart where the river widens to one mile after passing beneath the Roosevelt Bridge. Approximately three miles east, the river bends to the south, extending to the southernmost extension of Sewell Point, a spit of land separating the St. Lucie River from the Indian River Lagoon to the east. At Sewell Point, both bodies of water empty into the Atlantic Ocean at the St. Lucie Inlet.

The Caloosahatchee Estuary is part of the southern portion of Charlotte Harbor, which includes the estuary, San Carlos Bay, Pine Island Sound, and Matlacha Pass. The estuary extends 29 miles from the W.P. Franklin Lock and Dam near Alva to Shell Point at its mouth in San Carlos Bay. San Carlos Bay, which is bounded by Sanibel Island and Pine Island, is located at the confluence of the river, Pine Island Sound, Matlacha Pass, and the Gulf of Mexico. The freshwater releases into the estuary are controlled by the Franklin Lock and Dam, which also serves as a barrier to salinity and tidal influences upstream.

The quantity, timing, and quality of freshwater inputs to estuaries are critical determinants of the structure and function of these ecosystems (Bulger et al., 1990). Freshwater flows provide critical functions and materials for estuaries, including:

- Nutrients for estuarine biota;
- Protection from predation by mature life stages that are intolerant of lower salinities or that are unable to find prey in naturally turbid estuarine waters;
- A range of salinity conditions for a variety of organisms with different requirements for growth and development; and
- Transportation and deposition of many estuarine-dependent larvae.

Relative to natural conditions, the releases from Lake Okeechobee and changes in the watersheds have significantly altered freshwater inputs to the St. Lucie and Caloosahatchee estuaries and have adversely affected the structure and function of these sensitive ecosystems. Typically, rainfall events produce a greater volume of runoff with higher peak flows. Releases from Lake Okeechobee can further increase both the magnitude and duration of these events.

The changes in freshwater inputs to the estuaries have short-term and long-term effects on these ecosystems. The most immediate effect of these changes is the magnification of the natural fluctuations of salinity in these estuaries. Estuarine species evolved under conditions of naturally fluctuating salinity levels, but excessive fluctuations can stress these ecosystems. As described by Bulger et al. (1990), excessive salinity fluctuations can keep estuarine biota in constant flux between organisms which favor higher salinity and those which favor lower salinity. If the fluctuations are extreme, appropriate salinity conditions do not last long enough for organisms to complete their life cycle, and the diversity of organisms is reduced to those few species which can tolerate the dramatic salinity fluctuations.

Even moderate releases (such as in Zone B of the LORS) can transform these estuarine systems into freshwater habitats after a few weeks of sustained releases. The estuarine species are displaced or expire during extended periods of low or high salinity. In addition, continuous flow releases tend to create critically low benthic oxygen levels at the transition zone between freshwater and seawater. These ecosystem perturbations affect more than just estuarine species, since estuaries provide critical nursery habitat for marine (offshore) finfish and invertebrate species. These adverse effects provided the impetus for instituting the pulse releases contained in Zone C of the LORS.

Typically, when regulatory releases are terminated, the salinity levels in these estuaries return to the normal range, and the ecosystems begin to recover. The estuarine species that were displaced or extirpated return or are replaced. The recovery period is commensurate with the rate and duration of the freshwater inputs to the estuaries.

Other longer-term effects of the regulatory releases from Lake Okeechobee on the St. Lucie and Caloosahatchee estuaries include sediment and nutrient effects. Both effects are related to the quality of the water releases from Lake Okeechobee, which contain suspended silt, clay, and organic material. Much of the suspended material settles onto the bottom of the St. Lucie Canal and the Caloosahatchee River during modest, non-regulatory releases. However, during regulatory releases (particularly the high release levels in Zone B and Zone A of the LORS) this material is resuspended and carried into the estuaries during the first few days of the release period.

Suspended material increases the turbidity of the water in the estuaries and blocks sunlight to seagrass communities in these estuaries. Some seagrass communities are smothered by the suspended material as it settles in the low-energy environment of the estuaries. Other seagrass communities are affected by the reduction in sunlight that results from increased turbidity. Nutrient effects result from the nitrates and phosphorus contained in Lake Okeechobee's water which are resuspended by the release flows and stimulate primary production in the estuaries.

Releases can imbalance nutrient cycling in these ecosystems, leading to algae blooms and subsequent declines in dissolved oxygen and further increases in turbidity.

The short-term and long-term ecological problems in these estuaries are not entirely attributable to the regulatory releases from Lake Okeechobee. These estuaries have perturbations from other sources that contribute to the stresses on these ecosystems. For instance, other estuarine tributaries deposit freshwater, sediments, and nutrients in these ecosystems, including heavy metals that are associated with agricultural pesticide use in the contributing watersheds.

7.2 FISHING AND OTHER ECONOMIC EFFECTS ON THE ESTUARIES

The ecological effects of the freshwater releases to the estuaries can lead to commercial and recreational fishing impacts. These potential economic effects are discussed below. There are other potential (non-fishing) economic effects from freshwater releases which are also associated with changes in estuarine water quality. These effects could include changes in: (1) waterfront property values if water quality degradation is severe or sustained and (2) the quantity or quality of recreation (and tourism) if the releases discolor the water at beaches or if the releases contribute to algae blooms that limit beach access. These non-fishing effects are beyond the scope of this investigation, but they are current sources of concern to local residents and businesses who enjoy the estuaries and depend on tourists who come to use them. For example, in the spring of 1998 the City of Sanibel received complaints from residents and tourists about the water quality effects of freshwater releases down the Caloosahatchee River and into San Carlos Bay and the Gulf of Mexico.

7.3 POTENTIAL EFFECTS ON FISHING IN ST. LUCIE ESTUARY

The potential economic effects of the alternative regulation schedules on fishing in the St. Lucie Estuary depend on how the hydrologic changes affect the ecology of the estuary and on how the ecological changes translate into changes in commercial and recreational fishing. The economic effects on commercial fishing might include changes in the size of the catch or the cost of fishing operations. For guided sportfishing, the economic effects might include changes in the income of the professional fishing guides. For recreational anglers, economic effects could result from changes in the quantity or quality of recreational fishing experiences. As evident in the discussions below, the linkages between the hydrology, ecology, and economics of fishing in the St. Lucie Estuary are highly uncertain. Nevertheless, the hydrologic information generated through the SFWMM simulations does have economic implications for fishing in the estuary.

As part of this investigation, a variety of individuals, organizations, and institutions were contacted to identify pertinent studies and individuals with expertise on the effects of Lake Okeechobee releases on the St. Lucie Estuary. Contacts included:

- Florida Oceanographic Society;
- Marine Research Council;
- Harbor Branch Oceanographic Institute;
- St. Lucie Initiative;
- St. Lucie River Coalition;
- Florida Marine Research Institute;
- Florida Sea Grant;
- Martin County;
- Indian River Lagoon National Estuary Program (NEP);
- Treasure Coast Regional Planning Council; and
- SFWMD.

7.3.1 Profile of Commercial and Recreational Fishing in the St. Lucie Estuary

A profile of commercial and recreational fishing in the St. Lucie Estuary can be constructed using field information and data from state and national fishing databases. Unfortunately, much of the available information about commercial and recreational fishing in the estuary is contained in studies and data sets for much larger geographic areas.

There is very little, if any, commercial fishing in the St. Lucie Estuary. The use of gill nets in Florida coastal waters was banned in 1994. Interviews with local fish houses (i.e., retailers) indicate that their supplies do not come from the estuary. However, there may be low levels of commercial fishing for finfish (using rod and reel or cast nets) and for crabs. In Martin County, there are 271 saltwater products licenses and 44 permits for blue crab fishing. Crabbing activity in the estuary is believed to be small.

Although there is little commercial fishing within the estuary proper, the St. Lucie Estuary has important ecological connections with offshore commercial fish stocks. As explored in Nelson et al. (1991), some commercial species of finfish and invertebrates inhabit estuaries year-round; however, a large number of species only use estuaries during portions of their life cycle. Most of these latter species fall into four general categories:

- Diadromous species, which use estuaries as migration corridors and, in some instances, nursery areas;
- Species that use estuaries for spawning, often at specific salinity levels;
- Species that spawn in marine waters near the mouths of estuaries and depend on tidal- and wind-driven currents to carry eggs, larvae, or early juveniles into estuary nursery areas; and,
- Species that enter into estuaries during certain times of the year to feed on abundant prey and/or utilize preferred habitats.

In 1990, the Indian River Lagoon, which adjoins the St. Lucie Estuary, was included in the NEP. The NEP targets nationally significant estuaries for assessment and development of management plans that will substantially enhance their ecological quality. While the NEP studies on Indian River Lagoon suggest that the freshwater flows from the St. Lucie Estuary may not significantly affect the lagoon, the studies do provide insight to the ecology of the St. Lucie Estuary. In particular, the Indian River Lagoon studies identified 20 species of commercial finfish and three species of shellfish (blue crab, hard clam, and oyster) in the lagoon that are estuarine dependent. The estuarine-dependent finfish include:

- Atlantic sheepshead;
- Bluefish;
- Croaker;
- Drum, black;
- Drum, red;
- Flounders;
- Jack, crevalle;
- King whiting;
- Mackerel, spanish;
- Menhaden;
- Mullet, silver;
- Mullet, striped;
- Permit;
- Pompano;
- Snapper, mangrove;
- Snapper, mutton;
- Snapper, yellowtail;
- Seatrout, spotted;
- Spot; and,
- Tripletail

Nelson et al. (1991) noted that the estuaries on Florida's east coast include large numbers of tropical Caribbean fauna. In addition, Nelson et al. determined that the number of species (including adults, juveniles, and larvae) in southeastern estuaries varies by season and by salinity zone. Estuarine utilization for all life stages is highest in summer and lowest in winter. The number of species present as larvae reaches a peak in April in the tidal freshwater, mixing, and seawater zones. In contrast, the numbers of juveniles and adults in the three zones peak during the summer months. In any given month, more species utilize these estuaries as juveniles than at any other life stage. Some common species, such as bluefish and gray snapper, are primarily found in the estuary as juveniles and adults, with spawning, eggs, and larval development occurring offshore. Other species, such as snook and tarpon, are tolerant of a wide range of salinity levels. Seasonal variations in species composition implies that the timing, as well as the quantity, of freshwater releases to the St. Lucie Estuary are critical determinants of their potential effects on the estuarine ecology.

The FFWCC, Fish and Wildlife Research Institute, maintains the Florida Marine Fisheries Information System, a database of commercial fish landings. Summaries of the 2001-2005 commercial landings for Martin County and St. Lucie County are presented in Table 7-1. The summaries include finfish, invertebrates, and bait shrimp. No shrimp landings were reported for Martin County and St. Lucie in 2004 and 2005. The poundage, trips, and value of finfish have varied widely over the last five years, with values ranging from one and one-half million dollars to more than four million dollars for Martin County and from more than two million dollars to more than five million dollars. In contrast, the invertebrate landings showed a steady increase in all three categories.

This data is complemented by Table 7-2, which contains the top commercial landings (by weight) in Martin and St. Lucie Counties during 2005. The listed species each account for at least 1.5 percent of the total county catch by weight for Martin and St. Lucie Counties; 2,107,285 and 1,640,536 pounds, respectively. Together, these counties account for 86.4 and 82.4 percent of the total catch. Most of the species on this list reside in estuarine habitat for at least part of their life cycle.

TABLE 7-1
COMMERCIAL LANDINGS
MARTIN AND ST. LUCIE COUNTIES
2001-2005

MARTIN COUNTY		2001	2002	2003	2004	2005
Finfish	Pounds	1,095,994	1,058,507	2,086,882	2,750,949	2,107,285
	Trips	3,262	3,536	5,659	6,394	5,470
	Value	\$1,545,352	\$1,492,495	\$2,942,504	\$3,878,838	\$2,971,272
Invertebrates	Pounds	20,728	18,052	25,394	28,956	41,806
	Trips	224	201	220	283	848
	Value	\$56,380	\$49,101	\$69,072	\$78,760	\$113,712
Bait Shrimp	Pounds	0	0	0	0	0
	Trips	0	0	0	0	0
	Value	0	0	0	0	0

ST. LUCIE COUNTY		2001	2002	2003	2004	2005
Finfish	Pounds	3,753,475	3,163,073	3,212,649	2,208,580	1,640,536
	Trips	10,321	9,251	7,495	5,870	4,203
	Value	\$5,292,400	\$4,459,933	\$4,529,835	\$3,114,098	\$2,313,156
Invertebrates	Pounds	78,759	82,179	48,904	59,226	83,081
	Trips	567	716	571	518	505
	Value	\$214,224	\$223,527	\$133,019	\$161,095	\$225,980
Bait Shrimp	Pounds	1,129	166	110	0	0
	Trips	10	1	3	0	0
	Value	\$4,211	\$619	\$410	0	0

Source: Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 2006

TABLE 7-2
RANKED COMMERCIAL FINFISH LANDINGS BY WEIGHT
MARTIN COUNTY
2005

SPECIES	POUNDS	PERCENT OF TOTAL CATCH
Spanish Mackerel	1,276,678	60.6%
King Mackerel	334,880	15.9%
Mojarra	66,497	3.2%
Shark	56,484	2.7%
Sheepshead	53,200	2.5%
Popano	31,583	1.5%

ST. LUCIE COUNTY
2005

SPECIES	POUNDS	PERCENT OF TOTAL CATCH
Spanish Mackerel	478,326	29.2%
Shark	227,771	13.9%
Swordfish	170,755	10.4%
King Mackerel	138,564	8.5%
Black Mullet	100,292	6.1%
Crevalle Jack	67,578	4.1%
Silver Mullet	45,297	2.8%
Yellowfin Tuna	44,367	2.7%
Mojarra	38,637	2.4%
Dolphin	38,417	2.3%

Source: FF&WCC, F&WRI, Florida Marine Fisheries Information System, 2006

The St. Lucie Estuary also supports guided sportfishing and recreational fishing. According to interviews with local professional sportfishing guides, there are approximately 12 guides who operate in this estuary on a full-time basis. Charters typically fish for tarpon, spotted seatrout, snook, and red drum. Assuming that the guides charge an average of \$300 per day, guided sportfishing in the estuary would have an approximate annual value in excess of \$800,000. The guides indicate that while the majority of their charters consist of tourists, there are also a significant number of charters by Florida residents. Cited percentage ratios of resident/tourist charters were 40/60 for much of the year and 20/80 during the tourist season (i.e., winter and early spring).

Fishing in the St. Lucie Estuary is also popular with local anglers. Bell et al. (1982) have estimated that the overall economic value of recreational fisheries to a region can be as much as six times that from commercial fisheries. Unfortunately, no current participation rates for recreational fishing in the estuary could be identified during this investigation. However, a general impression of recreational fishing in the St. Lucie Estuary can be constructed using the following studies of recreational fishing in areas that include the estuary.

1. In a 1979 creel census of recreational anglers in the St. Lucie Estuary, Van Os et al. (1980) estimated that 338,797 fish were caught (446,820 pounds). The most abundant fish were sea catfish, but bluefish dominated the catch by weight.
2. The National Survey of Recreational Fishing conducted by the National Oceanic and Atmospheric Administration (NOAA) has collected recreational fishing data for the east and west coasts of Florida. The 1996 recreational landings for the east coast of Florida are presented in Table 7-3 for those species that account for at least one percent of the total catch. Since the survey is for cleeled fish, catch-and-release statistics are not available. For some gamefish, such as tarpon, catch-and-release accounts for the entire recreational fishery.
3. Bell et al. (1982) estimate that 61.5 percent of recreational fishing trips are within brackish coastal waters or within three miles of shore, where fisheries stocks are largely dependent on estuaries
4. Nelson et al. (1991) describe bluefish, gray snapper, spotted seatrout, spot, black drum, red drum, and gulf flounder as among the species that are abundant in the adjacent Indian River Lagoon, and by inference, in the St. Lucie Estuary.
5. Milon and Thunberg (1993) conducted a state-wide survey of resident anglers. Milon and Thunberg estimated that, on a state-wide basis, resident anglers make 8.7 fishing trips per year and that 56 percent of trips involved private boats. For Florida Marine Fisheries Commission Region 6, which includes the St. Lucie Estuary, Milon and Thunberg, estimated over 65 percent of the total fishing effort was expended in near-shore waters or within the estuary or lagoon complex. Their findings suggest that over 90 percent of the recreational fishing by Florida residents in Region 6 is done by people who reside in the lagoon watershed. In addition, Milon and Thunberg's surveys indicate that sea trout, snook, and red drum are the most popular species with anglers, pursued by 48 percent of the anglers who expressed species preference. The survey results suggest average state-wide daily expenditures by resident anglers of \$114.81, with annual expenditures of \$576.49 per fisherman. This is consistent with Bell's estimate of \$508.97 spent per fisherman on recreational fishing during 1982.

6. Bell (1993) investigated fishing by tourists to Florida. Bell estimated that of those tourists visiting Florida, 16.5 percent had engaged in saltwater fishing in the last year. However, 90 percent of the tourist anglers do not come primarily to fish, and two-thirds of these anglers have no target species. The tourists spend approximately \$110 per day while fishing.
7. Bell (1992) investigated the potential changes in tourist visitation resulting from adverse effects on recreational beaches and fisheries. Bell noted a state-wide decline in catch per trip from 5.8 to 4.5 fish/trip from 1979-1990. However, during the same period, he found no relationship between changes in tourism and changes in the catch rates of recreational saltwater fishing in the State.

**TABLE 7-3
RECREATIONAL LANDINGS
EAST COAST OF FLORIDA
1996**

Species	Landings	Percent
Saltwater catfishes	1,016,102	4%
Spot	878,155	3%
Jack, crevalle	840,862	3%
Mullets	752,765	3%
Other fishes	696,490	3%
Snapper, gray	584,592	2%
Drum, red	385,577	1%
Pinfishes	358,850	1%
Kingfishes	355,793	1%
Sheepshead	350,996	1%
Other grunts	205,466	1%
Herrings	188,775	1%
Bluefish	131,526	1%

Source: NOAA. National Survey of Recreational Fishing. 1997.

7.3.2 Hydrologic Changes Associated With Alternative Schedules

The SFWMM-simulated hydrologic effects of the alternative regulation schedules on the St. Lucie Estuary are presented in Table 7-4.

TABLE 7-4
SIMULATED HYDROLOGIC PERFORMANCE OF
ALTERNATIVE REGULATION SCHEDULES
ST. LUCIE ESTUARY

Performance Measure	07LORS	1bS2	1bS2_m	T1	T2	T3
Number of Mean Monthly Flows < 350	127	129	129	123	103	103
Number of Mean Monthly Flows 2000 to 3000	43	36	38	37	44	42
Number of Mean Monthly Flows > 3000	31	30	27	28	31	31

7.3.3 Potential Ecological and Economic Effects of Hydrologic Changes

There has been long-standing concern about the effects of regulatory releases on the St. Lucie Estuary. More than 20 years ago, conferences were sponsored by the Florida Oceanographic Society to discuss the ecological impacts of the regulatory releases. Over the years, the level of local awareness of the issues surrounding the ecological effects of the releases has varied in accordance with the release levels.

In 1998, a number of local interests expressed concern regarding the effects of the regulatory releases. Following the extremely wet spring induced by a strong El Nino event, high lake levels required Zone A releases into the St. Lucie Estuary under the Run25 schedule, with release volumes as high as 7,500 cubic feet per second (cfs). The brackish estuary was quickly transformed into a freshwater estuary, and the accumulated sediment on the canal bottom was quickly transported and deposited on the estuary benthos. The concerns of local residents were heightened when deformed mullet and gamefish with lesions were observed in the estuary. Water samples revealed the presence of *Cryptoperidiniopsis*, a marine algae, in the estuary. *Cryptoperidiniopsis* is being investigated by Florida Department of Environmental Protection (FDEP) as the potential cause of the lesions on fish in the estuary. However, at this time *Cryptoperidiniopsis* has not been linked to the lesions in the St. Lucie Estuary or to human health effects anywhere.

Based on available literature, some aspects of the relationship between regulatory releases and ecological effects on fishing are relatively clear. In general, the St. Lucie Estuary ecosystem is stressed by magnified oscillations in freshwater inputs to the estuary and other ecosystem perturbations. The stressors include Lake Okeechobee releases and other influences from the estuary's watershed. The variability in freshwater inputs to the estuary creates an unstable salinity environment (Chamberlain and Hayward, 1996). The turbidity and sedimentation

impacts on seagrass communities may be the principal long-term concern regarding freshwater inputs to the estuary (Haunert and Startzman, 1985). However, there are also concerns about the effects of low-flow periods, particularly with regard to dissolved oxygen levels. While in some instances the effects of releases may be difficult to distinguish from watershed effects, it appears that regulatory releases do affect commercial and recreational fisheries in the estuary (Haunert and Startzman, 1980; Van Os et al., 1980).

Unfortunately, there is a great deal of uncertainty regarding the effects of the freshwater releases from Lake Okeechobee on the St. Lucie Estuary. Estuarine ecosystems are complex, and the linkages between causes (e.g., ecosystem perturbations) and effects (e.g., changes in the structure or function of the ecosystem) are often unclear. There are multiple research topics that need to be explored to fully understand these linkages. These topics include distinguishing between: (1) the impacts of regulatory releases and runoff from the watershed, (2) short-term and long-term effects of the releases, (3) the few high level releases and the more numerous smaller events, and (4) low and high flow violations of the desired salinity targets.

Ecological uncertainties compound the economic uncertainties regarding commercial and recreational fishing. An example of the relationship between uncertainties in ecological and economic response to the regulatory releases is provided by the regulatory releases which occurred during the spring of 1998. During 1998 spring releases, gamefish disappeared due to the salinity effects, and the commercial and recreational fishery was severely impacted. However, by June of 1998, gamefish had returned to the estuary and guided sportfishing and recreational fishing had rebounded.

The economic effects would seem to be clearly bounded by the effects on fishing, since adult gamefish relocate during release periods (Van Os et al., 1980). However, the loss of juveniles and loss of habitat due to sedimentation effects on seagrass may not affect fishing and the economics of fishing for years to come. In addition, for those offshore commercial species that reside in estuarine waters during their larval or juvenile stages, the economic effects of changes in the estuarine ecology could be manifested in offshore commercial or recreational landings or in the landings of another county.

The challenge in determining the economic impacts on commercial and recreational fishing in the St. Lucie Estuary is further complicated by the need to differentiate between the with- and without-project future conditions in order to isolate the effects of the alternative regulation schedules. Given these considerations, the determination of an actual dollar estimate of the effects of the alternative plans on commercial and recreational fishing is beyond the limits of this investigation. However, the hydrologic effects of the alternative plans simulated in the SWFMM can be interpreted from the perspective of the fishing industry by combining the profile of commercial and recreational fishing with the current understanding of the ecological effects of regulatory releases on the estuary.

As indicated in Table 7-4, the alternative regulation schedules are all expected to result in improvements over the without-project future condition. However, the alternative regulation schedules are not expected to meet the performance targets. The relative performances of the alternative regulation schedules allow the plans to be compared, but the monetary estimation of

the economic effects on the commercial and recreational fishery will require additional research into the ecology and economics of the estuary.

The SFWMD is currently attempting to fill some of the information gaps that exist in the hydrology-ecology-economics chain of cause-and-effect as regards freshwater releases from Lake Okeechobee. In June 1998, the SFWMD sponsored a series of focus groups in Martin and St. Lucie counties that are intended to assemble local businesses affected by the large regulatory releases to the St. Lucie Estuary in the spring of 1998 and to identify the economic impacts on these businesses and the regional economy.

7.4 POTENTIAL EFFECTS ON FISHING IN CALOOSAHATCHEE ESTUARY

While the issues regarding Lake Okeechobee releases to the Caloosahatchee Estuary are similar to the St. Lucie Estuary, there are several important differences as well. Similarities include: (1) the purposes and timing of the regulatory and non-regulatory releases from Lake Okeechobee and (2) the uncertainties in the causal relationship between hydrologic changes in the releases, the consequent ecological effects, and the economic impacts on commercial and recreational fishing. Differences include: (1) the larger size of the Caloosahatchee Estuary relative to the St. Lucie Estuary, (2) the larger releases from the lake down this waterway, and (3) the ecological distinctions between the Caloosahatchee and St. Lucie estuaries.

As part of this investigation, a variety of individuals, organizations, and institutions were contacted to identify pertinent studies and individuals with expertise regarding the impacts of the freshwater releases from Lake Okeechobee on the Caloosahatchee Estuary. Contacts included:

- Harbor Branch Oceanographic Institute,
- Caloosahatchee River Citizens Committee,
- Lee County Professional Guides Association,
- Florida Marine Research Institute,
- Florida Sea Grant,
- Florida Bureau of Seafood and Aquaculture,
- Florida Center for Environmental Studies, Tarpon Bay Research Center,
- City of Sanibel,
- Lee County,
- Gulf of Mexico Program,
- Gulf of Mexico Foundation,
- Charlotte Harbor National Estuary Program,
- Southwest Florida Regional Planning Council, and
- SFWMD.

In 1995, Charlotte Harbor, which adjoins the Caloosahatchee Estuary, was included in the NEP. The Charlotte Harbor NEP effort included two studies with direct relevance for this investigation. The first is a review of the physical setting in the Caloosahatchee Estuary. The second is an estimate of the economic value of resources in the Charlotte Harbor study area, which includes the Caloosahatchee River.

Goodwin (1996) modeled the currents in the area of San Carlos Bay and concluded that much of the regulatory discharges from the Caloosahatchee River pass southward under the Sanibel Causeway and enter the Gulf of Mexico. However, under certain conditions, some of this freshwater can be transported into Pine Island Sound and Matlacha Pass. The extent of the

effects of regulatory releases from Lake Okeechobee is variable, depending on the release rate and the wind and tidal conditions in the estuary. Based on discussions with some of the previously listed organizations, the effects of large freshwater releases, such as those experienced in the spring of 1998, extend into San Carlos Bay, Matlacha Pass, Pine Island Sound, and Estero Bay. According to local residents, the tannin-colored waters from Lake Okeechobee are quite apparent as they darken the waters of San Carlos Bay.

It appears that the sedimentation effects of the releases on the Caloosahatchee Estuary are less problematic than the nutrient effects of the releases, relative to the St. Lucie Estuary. Red tides (i.e., marine algae blooms) were consistently described during interviews as a more significant ecological and economic threat than freshwater releases from Lake Okeechobee. Red tides kill fish, ruin fishing, and close beaches with the stench of dead fish and the effects of algae on bathers' respiratory systems (e.g., throat and sinus irritation). The two issues may be interconnected, since algae blooms have been linked to nutrient inputs to coastal waters. However, there are significant sources of nutrients in these coastal waters other than water released from Lake Okeechobee. Phosphate mining, agriculture, and wastewater discharges contribute to the nutrient levels in the coastal waters of Lee County.

7.4.1 Profile of Commercial and Recreational Fisheries

As in the case of the St. Lucie Estuary, a profile of commercial and recreational fishing in the Caloosahatchee Estuary can be constructed using field information and data in national and state fishing databases. Again, much of the available information about commercial and recreational fishing in the estuary is contained in studies and data sets for larger geographic areas.

There is some commercial fishing in the Caloosahatchee Estuary. The use of cast nets in the estuary is reported to be common. In addition, there is reported to be substantial crabbing activity in the estuary. In Lee County, there are 638 saltwater products licenses and 267 permits for blue crab fishing.

The Caloosahatchee Estuary has important ecological connections with offshore commercial fish stocks. As described in Nelson (1992), many commercial finfish and invertebrate species use estuaries for critical stages of their development. Table 7-5 presents commercial landings, trips, and value data collected by the FDEP for the Pine Island Sound/San Carlos Bay area. As indicated in this table, in 1997 the value of the commercial landings from this area were approximately \$1.7 million. The finfish and bait shrimp fisheries account for most of the landings and value. Although the shrimp landings in Table 7-5 are small, there is a significant offshore pink shrimp fishery that is based on Sanibel Island. This fishery is reflected in 1997 pink shrimp landings data for Lee County, which totaled 4,033,537 pounds. The Caloosahatchee Estuary and the area affected by freshwater releases from Lake Okeechobee comprise part of the nursery habitat for this fishery. The finfish and bait shrimp poundage, trips, and value data vary widely from year to year. This is due to changes in the fish population dynamics, fishing conditions, and fishing effort.

TABLE 7-5
COMMERCIAL LANDINGS
PINE ISLAND SOUND/SAN CARLOS BAY
1993-1997

		1993	1994	1995	1996	1997
Finfish	Pounds	1,084,476	174,582	260,175	479,160	1,036,342
	Trips	4,853	783	1,682	2,745	3,881
	Value	\$629,297	\$134,862	\$274,862	\$492,314	\$867,150
Invertebrates	Pounds	1,484	1,864	32,583	410,203	196,409
	Trips	11	13	111	1,391	1,373
	Value	\$1,435	\$1,299	\$31,560	\$219,301	\$247,464
Shrimp	Pounds	2,017	0	0	0	0
	Trips	9	0	0	0	0
	Value	\$6,250	\$0	\$0	\$0	\$0
Bait Shrimp	Pounds	89,165	114,982	118,009	136,356	147,564
	Trips	1,762	1,961	2,105	2,735	2,749
	Value	\$213,630	\$265,397	\$369,182	\$513,383	\$556,705

Source: FDEP, 1997

The data in Table 7-5 are complemented by the information in Table 7-6 and Table 7-7. Table 7-6 contains 1997 landings data from nearby Charlotte Harbor (to the north) and Estero Bay (to the south). As indicated in Table 7-6, the finfish fishery in Charlotte Harbor is substantially larger than that of the Pine Island/San Carlos Bay area.

Table 7-7 contains ranked landings of the top nine commercial species in Lee County, by weight. Each of these nine species accounts for at least one percent of the total county catch by weight (2,599,308 pounds) and together, they account for 95 percent of the total catch. Most of these species reside in estuarine habitat for at least part of their life stage. The 1997 commercial invertebrate landings for Lee County include: blue crabs (1,409,015 pounds) and stone crabs (151,330 pounds). In addition, the 1997 shrimp landings for Lee County were 4,224,879 pounds.

TABLE 7-6
COMMERCIAL LANDINGS
CHARLOTTE HARBOR; ESTERO BAY
1997

AREA	CATEGORY	POUNDS	TRIPS	VALUE
Charlotte Harbor	Finfish	1,787,612	6,103	\$1,293,085
	Invertebrates	748,850	4,446	\$701,355
	Shrimp	14,609	141	\$40,562
	Bait Shrimp	0	0	\$0
Estero Bay	Finfish	100,947	428	\$70,768
	Invertebrates	2,766	25	\$11,236
	Shrimp	0	0	\$0
	Bait Shrimp	0	0	\$0

Source: GDEP, 1997.

TABLE 7-7
RANKED COMMERCIAL FINFISH LANDINGS BY WEIGHT
LEE COUNTY
1997

SPECIES	POUNDS	PERCENT OF TOTAL
		CATCH
Mullet, Black	1,714,122	66%
Grouper, Red	270,762	10%
Pompano	134,932	5%
Mojarra	80,428	3%
Jack, Mixed	71,064	3%
Grouper, Gag	39,989	2%
Jack, Crevalle	33,991	1%
Ladyfish	30,758	1%
Grouper, Black	22,737	1%

Source: Florida Marine Fisheries Information System

The Caloosahatchee Estuary also supports guided sportfishing and recreational fisheries. Nelson (1992) described the following recreational species as "highly abundant", "abundant", or "common" in the Caloosahatchee Estuary: tarpon, sea catfish, snook, crevalle jack, silver perch, pinfish, spotted seatrout, red drum, black drum, and striped mullet.

According to interviews with the Lee County Professional Guides Association, there are approximately 60 guides who operate in Lee County, mostly on a full-time basis. Many of the guides fish in the Caloosahatchee River at least some of the time. An even larger number of guides fish in the area that is potentially subject to the effects of Lake Okeechobee releases. It appears that guides will frequently take charters into the Caloosahatchee River to fish for tarpon or to escape windy conditions on the coast. Guides in the area typically pursue tarpon, spotted seatrout, snook, and red drum. Assuming that the guides charge an average of \$350 per day, guided sportfishing in the area would have an approximate annual value of \$4.8 million. The guides indicate that while the majority of their charters consist of tourists, there are also significant numbers of charters by Florida residents. The ratio of resident/tourist charters of 40/60 was considered representative for much of the year, changing to 20/80 during the tourist season.

Recreational fishing in the Caloosahatchee Estuary is also popular with local anglers. Bell et al. (1982) estimated that the overall economic value of recreational fisheries to a region can be as much as six times that of commercial fisheries. Unfortunately, no current participation rates for recreational fishing in the estuary were identified as part of this investigation. However, a representative picture of recreational fishing in the Caloosahatchee Estuary can be constructed using studies of recreational fishing that include the estuary.

1. The 1996 National Survey of Recreational Fishing conducted by the NOAA for the west coast of Florida are presented in Table 7-8 for those species which account for at least one percent of the catch. Many of those species spend much of their lives in estuarine waters.
2. Bell et al. (1982) estimated that 61.5 percent of recreational fishing trips are within brackish coastal waters or within three miles of shore, where fish stocks are largely dependent on estuaries
3. The state-wide survey of resident anglers by Milon and Thunberg (1993) estimated that for the Florida Marine Fisheries Commission Region 3, which includes the Caloosahatchee Estuary, over 65 percent of the total fishing effort was expended in near-shore waters or within the estuary or lagoon complex. Milon and Thunberg's findings suggest that 88 percent of the recreational fishing by Florida residents in the lagoon is done by people who reside in the region. In addition, their surveys indicate that sea trout, snook, and red drum are the most popular species with anglers, pursued by 48 percent of the anglers who expressed species preference.
4. Bell's (1993) study of fishing by Florida tourists estimated that 16.5 percent of tourists visiting Florida engaged in saltwater fishing in the last year. However, 90 percent of the tourist anglers do not come primarily to fish, and two-thirds of these anglers have no target species

TABLE 7-8
RECREATIONAL LANDINGS
WEST COAST OF FLORIDA
1996

SPECIES	LANDINGS	PERCENT
Seatrout, spotted	2,762,297	11%
Pinfishes	2,486,234	10%
Sheepshead	896,605	3%
Saltwater catfishes	866,782	3%
Snapper, gray	818,934	3%
Drum, red	732,176	3%
Jack, crevalle	663,931	3%
Mullets	278,833	1%
Groupers	263,856	1%
Perch, silver	236,575	1%
Grunt, white	221,545	1%
Pigfish	194,270	1%
Seatrout, sand	183,686	1%

Source: NOAA. National Survey of Recreational Marine Fishing. 1996.

Lee County is also home to an emerging aquaculture industry. Since the State of Florida instituted the gill net ban in 1994, it has encouraged aquaculture to mitigate the economic effects on watermen and coastal communities and to meet the growing demand for seafood. In Lee County, there are over ten aquaculture farms, which primarily raise hard clams. The Harbor Branch Oceanographic Institute received a State grant to provide technical support for clam aquaculture. Some of these operations raise seed clams for sale to other aquaculture farmers; others raise mature clams for commercial sale. The seed clam operations typically use a closed (recycling) water system. The clam farms which are raising mature clams in Lee County are located in Pine Island Sound near the midpoint of Pine Island. It is anticipated that the releases from Lake Okeechobee will not have a significant effect on aquaculture operations in Lee County for two reasons: (1) the seed clams, which are potentially vulnerable to sudden and drastic salinity changes, are not exposed to the freshwater releases from the Caloosahatchee River and (2) the clam farms that raise clams to maturity are sufficiently removed from the more extreme effects of the freshwater releases.

7.4.2 Hydrologic Changes Associated With Alternative Regulation Schedules

TABLE 7-9
SIMULATED HYDROLOGIC PERFORMANCE OF ALTERNATIVE PLANS
CALOOSAHATCHEE ESTUARY

Performance Measure	07LORS	1bS2	1bs2_m	T1	T2	T3
Number of Mean Monthly Flows < 450	198	104	105	116	131	131
Number of Mean Monthly Flows 2800 to 4500	45	32	35	35	34	35
Number of Mean Monthly Flows > 4500	29	36	35	34	29	29

7.4.3 Potential Ecological and Economic Effects of Hydrologic Changes

Based on available literature, some aspects of the relationship between the regulatory releases and effects on fishing are relatively clear. In general, the Caloosahatchee Estuary ecosystem is stressed by the magnified oscillations in freshwater inputs to the estuary and other ecosystem perturbations. The stressors include the Lake Okeechobee releases and other influences from the estuary's contributing watershed. As in the St. Lucie Estuary, the variability in freshwater inputs to the Caloosahatchee Estuary creates an unstable salinity environment. The work of Doering and Chamberlain (1997) suggests that turbidity and dissolved oxygen levels are comparable to other Florida estuaries, but nitrogen concentrations are relatively high. Doering and Chamberlin also noted that, in general, water quality deteriorates with distance upstream from the mouth of the estuary. While in some instances the effects of the releases may be difficult to distinguish from effects of the Caloosahatchee River's relatively large watershed, it appears that the regulatory releases affect the commercial and recreational fisheries in the estuary.

Unfortunately, as in the case of the St. Lucie Estuary, there is a great deal of uncertainty regarding the effects of the freshwater releases from Lake Okeechobee on the Caloosahatchee Estuary. Estuarine ecosystems are complex, and the linkages between causes (e.g., ecosystem perturbations) and effects (e.g., changes in the structure or function of the ecosystem) are often unclear. There are multiple research topics that need to be explored to fully understand these linkages. These topics include distinguishing between the effects of: (1) the impacts of lake releases and freshwater inflow from the watershed, (2) short-term and long-term effects of the releases, (3) the few high level releases and the more numerous smaller events, and (4) low and high flow violations of the desired salinity envelope.

The ecological uncertainties compound the economic uncertainties regarding commercial and recreational fishing. As in the St. Lucie Estuary, the return of gamefish following a period of large releases to the estuary may not fully reflect the impacts on the fisheries. The economic effects would seem to be clearly bounded by the effects on fishing, since adult gamefish relocate during release periods (Van Os et al., 1980). However, the loss of juveniles and loss of habitat

due to impacts on seagrass communities may not affect fishing and the economics of fishing for years to come.

The challenge in estimating the economic effects on commercial and recreational fishing in the Caloosahatchee Estuary is further complicated by the need to differentiate between the with- and without-project future conditions in order to isolate the effects of the alternative regulation schedules. Given these considerations, the determination of a dollar value of the effects of the alternative plans is beyond the scope of this investigation. However, the simulated hydrologic effects of the alternative plans can be interpreted from the perspective of the economics of commercial fishing by combining the profile of commercial and recreational fishing with current understanding of the ecological effects of regulatory releases on the estuary.

As indicated in Table 7-9, the alternative regulation schedules are expected to result in improvements over the without-project future condition with respect to low and high water inputs to the Caloosahatchee Estuary. However, the alternative regulation schedules are not expected to meet the performance targets. The relative performances of the alternative regulation schedules allow the plans to be ranked, but the monetary estimation of the economic effects on the commercial and recreational fishery will require additional research into the ecology and economics of the estuary.

7.5 SUMMARY OF POTENTIAL ECONOMIC EFFECTS ON FISHING

The potential effects of the alternative LORS are summarized in Table 7-10. This table presents estimates of current annual revenues for each of the fisheries under consideration. As described in the above discussions, these estimates were generated using a variety of approaches and data sources. Consequently, the estimates should be considered approximate, and comparisons of the revenues of one fishery with another should be made with caution. Table 7-10 also contains information on the anticipated hydrologic performance of the alternative regulation schedules. In general, the alternative plans are expected to comprise improvements over the without-project future conditions. The economic interpretation of this hydrologic information suggests that the alternative plans could result in improvements in the economics of commercial and recreational fishing relative to the existing and without-project future conditions. The quantification of the expected economic impacts is not possible at this time given knowledge and data gaps in the sequence of hydrologic, ecological, and economic effects that determine economic impacts of the alternative regulation schedules.

TABLE 7-10
SUMMARY OF ECONOMIC EFFECTS OF ALTERNATIVE PLANS
ON ESTUARINE FISHERIES

Area	Approximate Annual Revenues of Fishery (\$ million)			Hydrologic Performance		Economic Interpretation of Hydrologic Performance
	Commercial	Guided	Recreational	Without-Project Conditions	Relative to Targets	
St. Lucie Estuary	\$1.7	\$0.8	n.a.	Alternatives meet or exceed Run25 performance	Alternatives do not meet targets	Positive economic impacts expected with alternative regulation schedules
Caloosahatchee Estuary	\$1.7	\$4.8	n.a.	Alternatives meet or exceed Run25 performance	Alternatives do not meet targets	Positive economic impacts expected with alternative regulation schedules

8. REGIONAL ECONOMIC IMPACTS

OVERVIEW

This chapter examines the potential effects of the alternative regulation schedules on the RED account. The RED account registers indirect and secondary effects to the region that are expected to result from the direct economic effects of the alternative plans. Direct economic effects represent the impacts of economic stimuli in terms of changes in regional industrial output, earnings, or employment. Indirect economic impacts represent the resultant economic changes in the industries that support and rely upon the industries directly affected by the stimuli. In addition, induced economic impacts are those impacts experienced by all local industries as direct and indirect effects alter household income and ultimately change local household spending patterns.

8.1 METHODOLOGY

A regional input-output model, *IMPLAN*, was used to estimate the RED effects of the alternative LORS. Regional input-output (I-O) analysis provides the classic tool for tracing economic ripples through the economy. Based on the region's industrial structure, I-O analysis tracks the expected inter-industry flow of goods and services. For the RED analysis, the regional economy was defined as encompassing 13 Florida counties (Broward, Charlotte, Collier, Dade, Glades, Hendry, Highlands, Lee, Martin, Monroe, Okeechobee, Palm Beach, and St. Lucie) using *IMPLAN*. Using county-level economic data, which was procured from the software vendor, the model was used to estimate the economic effects of the alternative regulation schedules on wages, employment, and industrial output. Specifically, *IMPLAN* was employed in a four-part methodology to: (1) describe the study area economy, (2) create economic scenarios, (3) introduce economic changes, and (4) estimate resulting direct, indirect, and induced economic effects.

Economic scenarios were created in *IMPLAN* to characterize the future conditions in each industry under each regulation alternative. Not all of the potential direct effects can be evaluated in the RED analysis. For example, it was not possible to evaluate the M&I water supply effects of the alternative plans in the RED account. The M&I water supply effects associated with the alternative regulation schedules were developed using WTP estimates for water supplies that would be unavailable during water shortages. Industrial water users may experience monetary income losses associated with water use cutbacks during shortages, but these effects cannot be distinguished from the combined WTP values derived from a survey of industrial, commercial, and residential users. In addition, commercial and residential water users primarily experience non-monetary effects from water shortages, representing their loss of satisfaction, rather than a reduction in household income.

Similar WTP issues precluded some agricultural water supply effects from inclusion in the RED account. Specifically, urban landscape and golf turf effects were calculated using WTP estimates. Since these estimates also represent reductions in satisfaction, not reductions in income, they were excluded from the RED analysis. In addition to M&I water supply and several agricultural water supply categories, three other NED categories

(e.g., commercial navigation, recreation, and commercial fishing) were not evaluated in the RED analysis. There are two principal reasons for this exclusion. First, the alternative regulation schedules are expected to have minor economic consequences associated with commercial navigation, recreation, and commercial fishing. Second, the procedures used to estimate the NED effects on these economic categories generated illustrative scenarios, not quantitative estimates of NED effects. Consequently, interpretations of their results should be limited to comparisons of the alternative plans.

Recognizing these exclusions, the RED analysis focused on the indirect and induced effects of the agricultural water supply impacts of the alternative regulation schedules. The total agricultural water supply effects generated using the SFWMM's EPP for each service area were developed in Chapter 2 of this report. For the RED analysis, these values have been distributed into the nine agricultural sectors used by the SFWMM and its EPP: urban landscape, sod, nursery, golf turf, tomatoes, avocados, citrus, rice, and sugarcane (see Table 8-1). The agricultural effects (i.e., the value of unmet demand) presented in Table 8-1 represent changes in farm income (or industry output) associated with each alternative regulation schedule and the without-project condition (LORS2007).

TABLE 8-1
SIMULATED 2006 AVERAGE ANNUAL VALUE OF
UNMET AGRICULTURAL WATER DEMAND
BY AGRICULTURAL SECTOR IN THE LEC AND EAA

EPP LAND USE CATEGORY	ALTERNATIVE REGULATION SCHEDULES					
	2007LORS	1bs2	1bs2_m	T1	T2	T3
Urban landscape	\$0	\$0	\$0	\$0	\$0	\$0
Other – Sod	\$0	\$0	\$0	\$0	\$0	\$0
Nursery	\$0	\$0	\$0	\$0	\$0	\$0
Golf turf	\$0	\$0	\$0	\$0	\$0	\$0
Tomatoes (vegetables)	\$0	\$0	\$0	\$0	\$0	\$0
Citrus	\$0	\$0	\$0	\$0	\$0	\$0
Avocado	\$0	\$0	\$0	\$0	\$0	\$0
Rice	\$0	\$0	\$0	\$0	\$0	\$0
Sugarcane	\$71,500	\$102,500	\$106,000	\$103,000	\$148,000	\$143,500
Total	\$71,500	\$102,500	\$106,000	\$103,000	\$148,000	\$143,500

8.2 RESULTS

In Table 8-2, the direct economic effects and aggregated indirect and induced economic effects are presented for the alternative schedules. These tables contain the direct effects of the alternative plans to seven agricultural sectors, commercial navigation, recreation, and commercial fishing. The combined induced and indirect effects, summarized in these tables represent the RED effects for all other industries affected by changes in the agricultural, commercial navigation, recreation and commercial fishing industries. Again, RED effects resulting from reductions in M&I water use and the agricultural uses of urban landscape and golf turf have not been estimated. Economic impacts to total industry output and employee compensation are expected to persist through each project year, while employment effects represent the total job loss or gain over the entire project period. Wages include salaries, non-wage compensation, and benefits. Employment is measured as the number of jobs, not necessarily full-time equivalents.

Due to the lack of impacts to non-sugar agriculture entities, the RED analyses of the five alternative regulation schedules focus on their estimated effects on the sugar industry, specifically yields of sugarcane agriculture. While the *IMPLAN* I-O software does not explicitly describe the linkages between direct and indirect or induced effects, presumably the consequent impacts of the reduced sugarcane production on sugar mills and other sugar-related activities are registered in the following regional economic sectors: sugar crops, food and manufacturing, and transportation and communication.

Regional statistics (MIG, 2005) indicate that the annual total industry output, employee compensation and employment in the study area are \$377.4 billion annually, \$128.7 billion annually, and 2.9 million respectively in 2003 dollars. The percentage of region total values listed in Table 8.4 show that across the study region, all economic impacts are negligible when compared to the region as a whole.

Tables 8-2 and 8-3 present the *IMPLAN* output for direct, indirect, and induced impacts of the five alternatives, while Table 8-4 is an aggregate of both, and their percentage of overall regional impacts.

TABLE 8-2
DIRECT, INDIRECT AND INDUCED IMPACTS ON EMPLOYEE COMPENSATION
AS A RESULT OF ALTERNATIVE MODEL RUNS (2003 DOLLARS)

ALTERNATIVE	Direct	Indirect	Induced	Total
2007LORS	\$-6,232	\$-1,638	\$-2,838	\$-10,708
1BS2	\$-8,938	\$-2,349	\$-4,071	\$-15,358
1BS2_M	\$-9,242	\$-2,429	\$-4,209	\$-15,879
T1	\$-8,998	\$-2,365	\$-4,098	\$-15,462
T2	\$-12,895	\$-3,389	\$-5,873	\$-22,157
T3	\$-12,513	\$-3,289	\$-5,699	\$-21,500

TABLE 8-3
DIRECT, INDIRECT AND INDUCED IMPACTS ON REGIONAL INDUSTRY
OUTPUT AS A RESULT OF ALTERNATIVE MODEL RUNS (2003 DOLLARS)

ALTERNATIVE	Direct	Indirect	Induced	Total
2007LORS	\$-42,250	\$-5,114	\$-8,944	\$-56,309
1BS2	\$-60,569	\$-7,335	\$-12,828	\$-80,759
1BS2_M	\$-62,652	\$-7,584	\$-13,263	\$-83,499
T1	\$-60,998	\$-7,384	\$-12,913	\$-81,294
T2	\$-87,421	\$-10,582	\$-18,507	\$-116,510
T3	\$-84,827	\$-10,268	\$-17,958	\$-113,053

TABLE 8-4
OVERALL REGIONAL NEGATIVE ECONOMIC IMPACTS OF THE
ALTERNATIVES (DIRECT AND INDIRECT IMPACTS)*

Alternative	Direct and Indirect Impacts		
	Output (2003 \$)	Employee Compensation (2003 \$)	Employment (FTE)
2007LORS	- 56,309	- 10,708	-1
% of Regional Total	<-.001%	<-.001%	<-.001%
1bs2	-80,759	-15,358	-1
% of Regional Total	<-.001%	<-.001%	<-.001%
1bs2_m	-83,499	-15,879	-1
% of Regional Total	<-.001%	<-.001%	<-.001%
T1	-81,294	-15,460	-1
% of Regional Total	<-.001%	<-.001%	<-.001%
T2	-116,510	-22,157	-1
% of Regional Total	<-.001%	<-.001%	<-.001%
T3	-113,053	-21,500	-1
% of Regional Total	<-.001%	<-.001%	<-.001%

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APPENDIX E

Simulation of Operational Alternatives For The Lake Okeechobee Regulation Schedule Study

Hydrologic Evaluation Final Report
Jacksonville Corps of Engineers
Water Resources Branch, Hydrologic Modeling Section

November 2007

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INTRODUCTION

Purpose and Scope of this Report

In support of the Lake Okeechobee Regulation Schedule Study (LORSS), the system-wide effectiveness of several alternative regulation schedules were simulated with the South Florida Water Management Model (SFWMM). The major assumptions and results of this effort are presented in this report to provide other study team members with information for further analysis. Also included in this report is a precursory evaluation of the trade-offs between the competing objectives for managing Lake Okeechobee.

The synthesis of the findings of these multiple analyses will be prepared by the U.S. Army Corps of Engineers (USACE). This report is intended to help document the characteristics of each alternative and provide a cursory review of the performance associated with each alternative.

Background

Lake Okeechobee is the second largest freshwater lake lying wholly within the boundaries of the United States. Lake Okeechobee benefits south Florida by storing enormous volumes of water during wet periods for subsequent environmental, urban and agricultural needs during dry periods. However, extended periods of high water levels within Lake Okeechobee have been identified as causing stress to the integrity of the Herbert Hoover Dike (HHD) as well as Lake Okeechobee's littoral zone. To accommodate south Florida's potential for heavy rains and severe tropical storms, a lower lake regulation schedule is desired to facilitate levee (HHD) remediation and to assist with long-term ecological restoration. This accommodation requires that water levels in the lake do not rise to levels that would threaten the structural integrity of the levee system surrounding Lake Okeechobee. Therefore, when water levels in the lake reach certain elevations designated by the regulation schedule, discharges are made through the major outlets to control excessive buildup of water in Lake Okeechobee. The timing and magnitude of these releases is not only important for preserving the flood protection of the region, but also for protecting the natural habitats of downstream estuaries and the Everglades.

The multiple objectives associated with managing Lake Okeechobee water levels are:

- Ensure public health and safety
- Manage Lake Okeechobee at optimal lake levels to allow recovery of the lake's environment and natural resources
- Reduce high regulatory releases to the Caloosahatchee and St. Lucie estuaries to ensure the health of the estuaries are not compromised
- Continue to meet Congressionally authorized project purposes including: flood control, water supply, navigation and recreation, as well as fish and wildlife enhancement

OVERVIEW OF THE SCHEDULES EVALUATED

This report presents the hydrologic simulation results and an evaluation of the hydrologic performance of the final array of regulation schedule alternatives designed to lower the normal operating limits of Lake Okeechobee while meeting the above objectives.

Following completion of the first draft LORSS Supplemental Environmental Impact Study (SEIS) in July 2006, the report was released for public comment and a series of public meetings were held in accordance with the National Environmental Policy Act (NEPA) process to allow the public time to express their views on the plan's effectiveness in managing Lake Okeechobee. Public meetings held on both the east and west coast with stakeholders and the general public provided valuable comments on the Tentatively Selected Plan (TSP) and draft SEIS report. These meetings provided a barometer of the general public's acceptance of the proposed regulation schedule. Recommendations, feedback and comments received were considerable, with many of the comments questioning the viability of the recommended plan. Feedback, especially from stakeholders and the general public on Florida's west coast were critical of the TSP, and concerns were raised that the plan did not go far enough in protecting the Caloosahatchee River and Estuary by further reducing the number of high flow releases being discharged from Lake Okeechobee. Stakeholders representing the Caloosahatchee Estuary expressed concerns that the TSP shows minimal benefits, if any, for the estuary. Concerns were also raised on the plan's impacts to water supply, navigation and on the Everglades ecology.

Based on the comments and recommendations received by the USACE following the completion of the LORSS public meetings, the decision was made to move forward with additional formulation and modeling in order to improve the performance of the recommended plan. During the formulation process and prior to the start of the new round of modeling, the USACE conducted a detailed review of the assumptions and data sets included in the original modeling. As with most projects, the modeling data sets and assumptions used for the LORSS evolved during the duration of the project, and the new round of modeling presented an opportunity to reset and ensure the most current data sets and assumptions were included for modeling evaluations of the TSP refinements resultant from the additional plan formulation.

The inclusion of updated assumptions and data sets required use of a modified version of the SFWMM. The model output included in the July 2006 draft LORSS SEIS (2006 SEIS) was not utilized during evaluation of the new modeling. Three alternatives from the 2006 SEIS were carried forward and modeled again with the updated assumptions and data sets used for the new round of modeling: the No Action Alternative (2007LORS), alternative 1bS2-m (July 2006 draft LORSS SEIS TSP), and alternative 1bS2-A17.25 (the simulation used as the starting point for development of alternative 1bS2-m). The model outputs for the alternatives included in the 2006 SEIS are comparable to each other, and the conclusions drawn from the comparisons between these original alternatives remain valid. The original alternatives from the 2006 SEIS represented a wider range of alternative regulation schedules than the new round of modeling, which built on the conclusions drawn from the detailed evaluation of the original alternatives by the LORSS Project Delivery Team (PDT).

To provide a complete documentation of the array of alternative regulation schedules evaluated for the LORSS, the following general overviews are provided in this section: the final seven alternative regulation schedules and No Action Alternative evaluated for the 2006 SEIS, documentation of updated assumptions and data sets used for the new round of modeling, and the final five alternative regulation schedules and No Action Alternative evaluated for the TSP refinements during additional plan formulation. The alternative descriptions include a listing of changes to the current Lake Okeechobee Regulation Schedule (LORS), Water Supply and Environment (WSE). Alternative descriptions include reference to the regulation schedule decision trees for releases to the Water Conservation Areas (WCAs) (Part 1), decision trees for releases to tide (Part 2), and regulation schedule zone or band breakpoints, which are provided in Attachment A of this Appendix. All elevations referenced within this Appendix for the regulation schedules or Lake Okeechobee stages refer to the National Geodetic Vertical Datum, 1929 (NGVD 1929).

The WSE regulation schedule divides Lake Okeechobee stages into regulation zones including Zone A, Zone B, Zone C, Zone D (including D1, D2, and D3), and Zone E. Modifications to these WSE regulation Zones are referenced in the alternative descriptions within this section. Following completion of the 2006 SEIS LORSS modeling, operations staff determined that the new LORSS would modify the terminology from Lake Okeechobee Zones to Lake Okeechobee Operational Bands, as follows: High Lake Management Band (comparable to WSE Zone A), High Band (Zone B), Intermediate Band (Zone C), Low Band (Zone D, including Zones D1, D2, and D3), a Base Flow Band (not included in WSE), and a Beneficial Use Band (Zone E).

Final Alternatives: 2006 LORSS SEIS

The final seven alternative regulation schedules, plus the No Action Alternative, include the following:

- The No Action Alternative: current regulation schedule, WSE, with the addition of temporary forward pumps;
- The LORS-FWO (future with operations modified) Alternative which is similar to the No Action Alternative with a general lowering of the top two regulatory release lines and the addition of a new regulatory base flow zone for the Caloosahatchee Estuary;
- Alternative 1bS2-A17.25 which is a similar approach to WSE with a general lowering of the top three regulatory release lines, reduced magnitude of maximum discharge decisions in Zone B and Zone C to the St. Lucie Estuary (SLE), a reshaping of the line representing the divide between Zone D and Zone E, redefinition of some of the WSE meteorological inputs, and the addition of a new regulatory base flow zone for the Calosahatchee Estuary;
- Alternative 1bS2-m which is similar to Alternative 1bS2-A17.25 but with a lowering of the second and third regulatory release lines and a lowering of the top three regulatory release lines during the late hurricane season from September 15 through November 1;
- Alternative 2a-B which represents a new approach to defining the regulatory release bands (based on a defined target operational guideline), and includes removal of the seasonal and multi-seasonal forecasting indices utilized under the WSE decision tree framework, and the addition of a new regulatory base flow zone for the Caloosahatchee Estuary;

- Alternative 2a-m which represents a more aggressive approach to Alternative 2a-B in passing low-level, non-damaging releases to the estuaries to further reduce the normal lake levels, and includes increased magnitude releases to tide in advance of reaching the highest release band;
- Alternative 3-B which represents an approach similar to Run22AZE, from the last regulation schedule study, but with a lowering of the upper two regulatory lines and addition of a new regulatory base flow zone for the Caloosahatchee Estuary;
- Alternative 4-A17.25, a more aggressive modification—but similar to—Alternative 1bS2-A17.25, which includes higher maximum release magnitudes to tide for Zone B and Zone C, increased maximum release magnitudes to tide under dry seasonal forecast in Zone C and Zone D, and lowering of the top three regulatory release lines during the late hurricane season.

With the exception of the No Action Alternative, the final set of alternatives, above, were developed to achieve a few common goals: to achieve zero or close-to-zero days above lake elevation of 17.25 ft NGVD; to provide a base flow to one or both of the estuaries in order to minimize the occurrence of undesirable high-volume releases to the estuaries; to include a maximum limit of the lake regulatory releases passed through Stormwater Treatment Area (STA) 3/4, based on assumed treatment capacity given the current nutrient levels within Lake Okeechobee; and to provide lake operators with as much flexibility as possible to lower the lake stages when needed to achieve the project objectives. All alternatives, except Alternative 2a-B and Alternative 2a-m, included similar use of the WSE meteorological guidelines and decision tree framework; all alternatives included use of the Tributary Hydrological Conditions (THC) indicators concept, as found in WSE but modified to utilize the Palmer Drought Index (PDSI) (in the place of net basin rainfall) and Lake Okeechobee net inflows (in the place of inflows at S-65E). The South Florida Water Management District (SFWMD) Supply Side Management (SSM) line is assumed to be lowered by one foot from the current SSM line under all alternatives. The assumption of a lowered SSM line serves as a surrogate for the water shortage management plan update effort anticipated to be completed by the SFWMD prior to implementation of a new lake regulation schedule (to be identified by this LORSS), but the assumption is unable to be included as part of the No Action Alternative; the assumption of a one-foot lowering of the SSM line for all alternatives is based on a recommendation from the SFWMD technical staff working on the parallel effort to update the SSM rules. Completion of the SFWMD water shortage management plan update effort requires identification of the TSP by the USACE.

The schedules which included the WSE decision tree framework were designed to increase operational flexibility. Considering the many competing purposes for managing Lake Okeechobee, it appears desirable to design flexible operating rules that give water managers some latitude to utilize best available multi-disciplinary information, and adjust operations as necessary to achieve a better balance of the competing objectives. Considering the potential benefits from recent lake inflow forecasting tools, and the rapid increase in the state-of-the-art in forecasting technology, it is practical to establish more flexible rules which allow lake managers to utilize supplemental information and apply their best professional judgement in making operational decisions. A detailed discussion of WSE will not be provided in this report; however, differences from WSE will be discussed as part of the individual alternatives.

A. LORS-FWO Alternative

The No Action Alternative, which includes the current WSE regulation schedule for Lake Okeechobee and assumes SFWMD temporary forward pumps in place, calls for maximum practicable releases from Lake Okeechobee when lake stages are within Zone A—a range from elevation 17.00 feet on May 31 to elevation 18.50 feet from October through March. The No Action Alternative does not include a zone for base flow releases to either the Caloosahatchee or St. Lucie Estuary. In order to properly evaluate the potential effects of allowing for maximum releases above 17.25 elevation and base flow to the estuaries, in the absence of additional changes to the WSE regulation schedule, alternative LORS-FWO was developed with the following changes to the No Action Alternative:

1. Zones A and B are lowered where necessary to allow maximum practicable releases under all conditions when the Lake Okeechobee stage exceeds 17.25 ft, NGVD. The regulation schedule is shown in Figure A-1.
2. An additional regulatory zone is added (below Zone D) to allow for base flow releases to the Caloosahatchee Estuary. During the alternative formulation process, data and recommendations were evaluated and the recommended base flow release was determined to be 450 cubic feet per second (cfs) to the Caloosahatchee Estuary (measured at S-79) and zero base flow to the SLE.

B. Alternative 1bS2-A17.25

Alternative 1bS2-A17.25 was developed from the current WSE decision tree structure. The regulation schedule and decision trees for Lake Okeechobee discharges to the WCAs and discharges to tidewater for Alternative 1bS2-A17.25 are shown in Figure A-2, Figure A-3, and Figure A-4, respectively. Operational experience under WSE and the availability of additional climatological data led to the following recommended modifications to WSE for this alternative:

1. Regulation schedule lines for Zone A, Zone B, and Zone C are lowered. If the stage of Lake Okeechobee exceeds 17.25 ft, NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater. The lowering of the upper regulatory zones results in a regulation schedule that is more pro-active in limiting potential high water conditions within Lake Okeechobee.
2. THC are applied that represent longer term wet or dry conditions that have persisted in the tributaries. Updated THC indicators enable the proposed regulation schedule to avoid frequent breaks in the regulatory outflows that may occur due to shorter dry periods. The PDSI is proposed to replace the 30-day net rainfall, and the 14-day mean Lake Okeechobee net inflow (LONIN) is proposed to replace the 14-day mean S-65E flow. The classification bands for the PDSI and LONIN THC indicators are summarized in Table 1.
3. The line representing the divide between Zone D and Zone E is reshaped; the bottom of Zone D is flattened during the periods in which the estuary ecological systems may be

more impacted by large freshwater discharges, especially in late winter, early spring, and during the October through November period. The modified regulatory line promotes a quicker response in the autumn and winter months to large inflows that often are generated during the hurricane season.

TABLE 1: DEFINITION OF TRIBUTARY CONDITIONS BASED ON THE PALMER DROUGHT INDEX AND NET INFLOW

Tributary Hydrologic Classification	Palmer Index Class Limits	2-wk mean L.O. Net Inflow Class Limits
Very Wet	3.0 or greater	Greater \geq 6000 cfs
Wet	1.5 to 2.99	2500-5999 cfs
Near Normal	-1.49 to 1.49	500-2499 cfs
Dry	-1.5 to -2.99	-5000 – 500 cfs
Very Dry	-3.0 or less	Less than -5000 cfs

4. A new base flow zone (Zone D0) is established below the bottom of the re-shaped Zone D. Base flow is allowed when Lake Okeechobee water levels are in Zone D0 or above (Zone C decision tree outcome for dry THC, seasonal, and multi-seasonal forecasts is base flow), but no base flow releases are called for when the stage falls below the bottom of Zone D (Zone D0). During the alternative formulation process, data and recommendations were evaluated and the recommended base flow release was determined to be 450 cfs to the Caloosahatchee Estuary (measured at S-79) and zero base flow to the SLE. Risks to the water supply performance objective are anticipated to be minimized with the forward pumps assumed in place to allow for water supply at lower lake water levels. The bottom of the base flow zone ranges from 11.5 ft, NGVD on May 31 to 13.0 feet during October and November. For Figure A-3 (discharges to WCAs), releases to the WCAs when in Zone D0 adhere to the same decision tree as the remainder of Zone D; for Figure A-4 (discharges to tidewater), releases when in Zone D0 will be base flow, and the decision tree of Zone D is not applicable.
5. THC and seasonal climate forecasts are updated to allow increased operational flexibility in managing lake stages, and specifically to avoid extreme high lake stages. A significant number of decision tree outcomes for THC and seasonal forecast are updated to allow the quicker release of lake water, as compared to WSE (for example, “Extremely wet” THC is changed to “very wet” or “wet to very wet” is changed to “normal to wet”). The additional inclusion of lake stages forecasted to rise into Zones A or B also introduces additional operator flexibility by allowing for utilization of all available hydrologic and meteorological forecasting data. The changes to WSE for Alternative 1bS2-A17.25 are indicated by the red font in Figure A-4.

6. Moderate to extreme high discharges to the SLE are reduced by modifying the maximum discharge rates for Zone B and Zone C from 3500 to 2800 cfs, and 2500 to 1800 cfs, respectively. The intention of this modification was to reduce the potential impacts associated with high-volume discharge events to the SLE.

C. Alternative 1bS2-m

Alternative 1bS2-A17.25 simulation output (SFWMM) showed the 17.25 feet stage criteria for Lake Okeechobee extreme high water to be exceeded for 12 days during the 36-year simulation period-of-record (POR). Alternative 1bS2-A17.25 was modified to remove any simulated daily stage in excess of 17.25 feet within Lake Okeechobee. The modifications to Alternative 1bS2-A17.25 to create Alternative 1bS2-m are summarized below:

1. Regulation Zones A, B, and C are lowered during the late hurricane season (September 30 stage breakpoints are changed to November 1).
2. Regulation lines for the bottom of Zones B and C were lowered. Zone B breakpoints were first lowered to be mid-way between the bottom of Zone A and the bottom of Zone C. The bottom of Zone B was then lowered by an additional 0.15 feet and the bottom of Zone C was lowered by 0.10 feet, as required to achieve zero days with lake stage greater than 17.25 ft elevation.

As the result of the modifications to develop Alternative 1bS2-m, the simulated peak stage for Lake Okeechobee is 17.23 feet. The peak stage of 17.23 feet is less than the maximum target stage identified to be 17.25 feet. The regulation schedule for Alternative 1bS2-m is shown in Figure A-5; the decision tree remains unchanged from Alternative 1bS2-A17.25 (Figure A-3 and Figure A-4).

D. Alternative 2a-B

Alternative 2a-B represents a new approach to defining the regulatory release bands, based on a defined target operational guideline. The regulation schedule and decision trees for Lake Okeechobee discharges to the WCAs and discharges to tidewater for Alternative 2a-B are shown in Figure A-6, Figure A-7, and Figure A-8, respectively. The operational details of Alternative 2a-B are summarized below:

1. The operational guideline was developed by the USACE Water Management Section based on evaluation of historical stages of Lake Okeechobee from 1965 through 2005. As the lake stages increase further above the operational guideline, regulatory releases increase according to the specified regulatory bands.
2. The upper two regulatory lines were defined based on the probability (50% and 25%) of Lake Okeechobee stages reaching 17.50 feet within the next 90 days, assuming discharge outlets to tidewater were significantly limited. If the stage of Lake Okeechobee exceeds 17.25 ft, NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater (same as Alternative 1bS2-A17.25).

3. Below the operational guideline, base flow to the Caloosahatchee Estuary of 450 cfs is permitted but discontinued if the lake falls below the assumed 12.56 feet elevation for navigation (Lake Okeechobee navigation may be impaired at lower stages) or the current SSM line, whichever is higher.
4. The decision tree for Alternative 2a-B includes removal of the seasonal and multi-seasonal forecasting indices utilized under the WSE decision tree framework, utilizing only the THC indicators of the PDSI and LONIN, as used in all alternatives.
5. Regulatory releases from Lake Okeechobee to the WCAs are discontinued when the lake stage falls below 13.50 ft, NGVD.

E. Alternative 2a-m

Alternative 2a-B was modified to significantly reduce the frequency of extreme high discharge to the Caloosahatchee and St. Lucie estuaries, with the resulting alternative being Alternative 2a-m. The modifications to Alternative 2a-B are summarized below, and the regulation schedule is shown in Figure A-9. The decision tree for Alternative 2a-m is unchanged from the decision tree utilized for Alternative 2a-B (Figure A-7 and Figure A-8).

1. Releases to tidewater for the regulatory band between the 25 percent and 50 percent high water probability lines (Blue band) are increased from 6500 cfs to Caloosahatchee/3500 cfs to St. Lucie to 7500 cfs/5000 cfs, with the intention to reduce the duration of extreme high-volume estuarine discharges but also recognizing the possibility that these higher release volumes may cause additional impacts to public health and safety downstream of the St. Lucie lock (S-80).
2. Releases to tidewater for the regulatory band between the operational guideline and 13.50 feet elevation (magenta band) is modified from a regulatory band for Caloosahatchee Estuary baseflow to a low level regulatory release of 800 cfs to the Caloosahatchee Estuary and 400 cfs to the SLE. The magenta regulatory band was also extended to include the area between 13.50 feet elevation and the operational guideline minimum elevation of 12.50 feet, which was not included for Alternative 2a-B.
3. The bottom of the base flow regulatory band (bottom of orange band/top of red band) was modified to be consistent with Alternative 1bS2-A17.25 and Alternative 1bS2-m, with a minimum elevation of 11.50 feet and a maximum elevation of 13.0 feet.

F. Alternative 3-B

The conceptualization for Alternative 3 was developed from Run22AZE. The operational schedule Run22AZE was evaluated under the previous LORSS (2000) that resulted in the selection of WSE, at which time Run22AZE was recommended as the most desirable schedule for the Lake Okeechobee littoral zone system. The regulation schedule for Run22AZE is shown in Figure A-10. The regulation schedule for Run22AZE was modified for this regulation schedule study with the following changes, as shown in Figure A-11:

1. The upper two regulatory lines are lowered. If the stage of Lake Okeechobee exceeds 17.25 ft, NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater (same as Alternative 1bS2-A17.25). The Run22AZE operational schedule included maximum practicable releases when stages exceeded 18.50 feet for October through February.
2. A new regulatory base flow zone for base flow to the Caloosahatchee Estuary is defined below the bottom regulatory line of the Run22AZE operational schedule. Base flow releases for the Caloosahatchee Estuary are discontinued if Lake Okeechobee falls below the assumed 12.56 feet elevation for navigation (Lake Okeechobee navigation may be impaired at lower stages) or the current SSM line, whichever is higher.

The operational criteria for releases to the WCAs and releases to the estuaries remain unchanged from the zones defined for Run22AZE; Zone A and Zone B breakpoints have, however, been modified as noted in item 1 above.

G. Alternative 4-A17.25

Alternative 4 was developed similarly to Alternative 1bS2-A17.25. Alternative 4, however, was intended to provide additional operational flexibility to manage the lake stages at lower levels than Alternative 1bS2-A17.25. The regulation schedule for Alternative 4 is shown in Figure A-12. Alternative 4 includes all of the modifications to the No Action Alternative that were included in Alternative 1bS2-A17.25, with the following additional modifications:

1. Maximum releases in Zone B and Zone C for normal to wet THC are unchanged from the No Action Alternative: 6500 cfs to Caloosahatchee Estuary/3500 cfs to SLE in Zone B and 4500 cfs/2500 cfs in Zone C. If the stage of Lake Okeechobee exceeds 17.25 feet, NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater (same as Alternative 1bS2-A17.25).
2. Regulation Zones A, B, and C are lowered during the late hurricane season (September 30 stage breakpoints are changed to November 1).
3. Zone D decision tree outcome for THC “normal” and seasonal climate outlook “otherwise” (not “normal or wetter”), or THC “wet” or “normal” and multi-season climate outlook “otherwise” (not “wet to very wet”) is changed from base flow to the Caloosahatchee Estuary to “up to level 1 pulse release.”
4. Zone C decision tree outcome for THC, seasonal climate outlook, and multi-season climate outlook “dry” is changed from base flow to the Caloosahatchee Estuary to “up to level 2 pulse release.”
5. Zone D0 for base flow to the Caloosahatchee Estuary is re-defined to discontinue base flow releases if Lake Okeechobee falls below the assumed 12.56 feet elevation for navigation (Lake Okeechobee navigation may be impaired at lower stages) or the current

SSM line, whichever is higher (Alternative 1bS2-A17.25 allowed base flow to elevation 11.50 feet at the minimum).

6. Consideration of active hurricane season forecast was recommended for inclusion with the THC decision, but this variable was not defined in detail adequate for SFWMM modeling, and it was therefore not included in the Alternative 4 simulation.

Additional assumptions common to all previous alternatives are next briefly reviewed. All alternatives include the SFWMD temporary forward pumps at S-351, S-352, and S-354 for water supply, as included in the No Action Alternative. The regulation schedules for the WCAs (including WCA-1, WCA-2A, WCA-2B, WCA-3A, and WCA-3B), including environmental water supply deliveries from Lake Okeechobee, are not modified from the No Action Alternative for the LORSS alternatives. For alternatives formulated to include base flow releases to the Caloosahatchee and/or St. Lucie Estuaries (measured at S-79 and S-80, respectively) when Lake Okeechobee stages are within an established base flow regulatory band, it is recognized that very dry climate conditions may require that releases to the estuaries be discontinued; this note will be included on the 2007 LORSS regulation schedule, and this consideration is represented in the SFWMM simulations with a 0.50 million acre-feet threshold for the multi-seasonal forecast of Lake Okeechobee inflow (base flow releases are discontinued if the inflow forecast is below this threshold). All alternatives assume backflow from the St. Lucie Canal (C-44) to Lake Okeechobee to be allowed to occur at lake stages of 14.50 feet or 0.25 feet below the bottom of the lowest non-baseflow regulatory zone, whichever is lower. These operations were developed to achieve similar performance as the No Action Alternative, while seeking to avoid frequency oscillation between regulatory releases and backflow at S-308. The No Action Alternative assumes backflow below Lake Okeechobee stages of 14.50 feet, consistent with operations under WSE and always more than 0.25 feet below the lowest regulatory release zone for the WSE regulation schedule. All LORSS alternatives and the No Action Alternative assume backflow from the Caloosahatchee River Canal (C-43) to Lake Okeechobee to be allowed to occur for lake stages below 11.10 feet. Operations for gravity flow from the West Palm Beach Canal and L-8 Canal to Lake Okeechobee are not modified from the No Action Alternative for the LORSS alternatives and remain consistent with existing operations.

SFWMM Updates: 2007 LORSS SEIS

Based on the comments and recommendations received by the USACE following the completion of the LORSS public meetings to review the 2006 SEIS, the decision was made to move forward with additional formulation and modeling in order to improve the performance of the 2006 SEIS recommended plan. During the formulation process and prior to the start of the new round of modeling, the USACE conducted a detailed review of the assumptions and data sets included in the original modeling. The inclusion of updated assumptions and data sets required use of a modified version of the SFWMM. Three alternatives from the 2006 SEIS were carried forward and modeled again with the updated assumptions and data sets used for the new round of modeling: the No Action Alternative (2007LORS), alternative 1bS2-m (July 2006 draft LORSS SEIS TSP), and alternative 1bS2-A17.25 (the simulation used as the starting point for development of alternative 1bS2-m). Documentation of updated assumptions and data sets used for the new round of modeling are provided below:

A. Documentation for Updated 2007LORS base condition

1. The seasonal and multi-seasonal forecast files used until July 2006 (as used for the previous LORSS modeling) for all SFWMM modeling was mistakenly computed with La Nina threshold of -0.04. The updated base condition simulation is corrected by utilizing re-computed seasonal and multi-seasonal forecast input data files based on the correct threshold. The La Nina threshold error dates back to the 2005 Lower East Coast Water Supply Plan (LECRWSP) simulation, selected as the best available SFWMM representation of WSE operations in February 2006 (start of the LORSS alternative modeling). The LONIN control volume used in the computation is based on S-80, which is specified in the WSE Water Control Plan (WCP).
2. SFWMD recommends use of the pump option at the S-8 structure to provide additional water supply deliveries to the Big Cypress Seminole Tribe reservation. Previous base condition and alternative modeling assumed gravity deliveries. Based on discussions with SFWMD staff, the pump operation is likely to be used to ensure delivery of water supply, specifically under drought conditions.
3. The SFWMM subroutine that computes the capacity of the Everglades Agricultural Area (EAA) canals under the neutral case had some legacy code that made it rely on parameter values for other "Low Lake Okeechobee Stage Management" (as opposed to using the SSM operations). The source code was modified to correct this minor error. Updated source code was provided to USACE by SFWMD on 06 October 2006 and utilized to update the base condition simulation of 2007LORS.
4. L-8 regulatory releases from Lake Okeechobee and L-8 local basin runoff are routed to tide (through S-155A) and will not be routed through STA-1E. Based on discussions with SFWMD and USACE technical staff, STA-1E is not designed to treat L-8 local basin runoff or Lake Okeechobee discharges (associated with higher nutrient load). Previous LORSS base condition and alternative modeling assumed treatment of L-8 local basin runoff and Lake Okeechobee discharges by STA-1E, resulting in additional volumes of water being passed through STA-1E, WCA-1, WCA-2, and into WCA-3A. Updated source code was provided to USACE by SFWMD on 06 October 2006 utilized to update the base condition simulation of 2007LORS.

The updated simulation for the 2007LORS base condition was developed from the 2007LORS base condition simulation evaluated in the 2006 SEIS, and the simulation is updated to include the above assumptions and new SFWMM source code.

B. Documentation for Updated LORSS alternatives (1bS2-A17.25 and 1bS2-m)

1. The seasonal and multi-seasonal forecast files used up to July 2006 (as used for the previous LORSS modeling) was mistakenly computed with La Nina threshold of -0.04. The updated base alternative simulations are corrected by utilizing re-computed seasonal and multi-seasonal forecast input data files based on the correct threshold.

A new time series developed for updated computation of LONIN, based on a control volume that includes the S308 structure. The previous LORSS base conditions and alternatives were simulated with a time series for a control volume that included S-80. Updated input files for the seasonal and multi-seasonal forecast, as well as THCs were provided by the SFWMD on 13 October 2006, and the updated assumptions were reviewed and supported by the USACE water management technical staff.

The following equation was used for the computation:

$$\text{LONIN} = \text{DeltaStorage} + \text{L8CP} + \text{HG5} + \text{S2} + \text{S3} + \text{S308} + \text{S77}$$

Minor formatting problems in the THC input data files were also identified and corrected.

The updated input files for seasonal and multi-seasonal forecasts and THC used for the alternatives were computed based on the correct La Nina threshold and changed control volume for LONIN that includes S-308 (not S-80); the updated alternatives include the THC shift to LONIN and PDSI from S-65E discharge and net rainfall THCs used under WSE; the LONIN Time series was updated based on the S-308 control volume (consistent with the intent of the original alternative 1b proposed by the SFWMD).

2. SFWMD recommends use of the pump option at the S-8 structure to provide additional water supply deliveries to the Big Cypress Seminole Tribe reservation. Previous base condition and alternative modeling assumed gravity deliveries. Based on discussions with SFWMD staff, the pump operation is likely to be used to ensure delivery of water supply, specifically under drought conditions.
3. The SFWMM subroutine that computes the capacity of the EAA canals under the neutral case had some legacy code that made it rely on parameter values for other "Low Lake Okeechobee Stage Management" (as opposed to using the SSM operations). The source code was modified to correct this minor error. Updated source code was provided to USACE by SFWMD on 06 October 2006 and utilized to update the alternatives.
4. L-8 regulatory releases from Lake Okeechobee and L-8 local basin runoff are routed to tide (through S-155A) and will not be routed through STA-1E. Based on discussions with SFWMD and USACE technical staff, STA-1E is not designed to treat L-8 local basin runoff or Lake Okeechobee discharges (associated with higher nutrient load). Previous LORSS base condition and alternative modeling assumed treatment of L-8 local basin runoff and Lake Okeechobee discharges by STA-1E, resulting in additional volumes of water being passed through STA-1E, WCA-1, WCA-2, and into WCA-3A. Updated source code was provided to USACE by SFWMD on 06 October 2006 and was utilized to update the alternatives.
5. Updated SSM water shortage management plan methodology (termed Lake Okeechobee Water Shortage Management Plan [LOWSM] by the SFWMD) is included in the updated modeling. 2006 SEIS alternative simulations assumed a one-foot lowering of

the SSM line as a surrogate for this LOWSM plan that was under development by the SFWMD. The operational details of the draft LOWSM plan were provided to the LORSS PDT by the SFWMD on 10 October 2006. Appendix G of the LORSS revised draft (June 2007) SEIS (included as attachment 1 to appendix G of this Final SEIS) was prepared by the District to advise the USACE of the details and development history for the refined LOWSM plan. Attachment 1 (prepared by the District in February 2007) provides complete documentation of the development history behind the LOWSM trigger lines and operational rules that were assumed for the alternative evaluations provided within the LORSS revised draft (June 2007) SEIS, based on the District recommendations, and repeated within the LORSS Final SEIS.

Updated source code was provided to USACE by SFWMD and was utilized to update the alternatives.

The LOWSM methodology is not included within the base condition simulation (2007LORS) and separate SFWMM code versions were used to simulate the base condition and all alternatives included in the new round of modeling. The LOWSM option is controlled by input file parameters, and the same source code could have been used for alternatives and base if no additional changes were required; however, minor code changes to the Lake Okeechobee decision tree are also included in the source code used to simulate the alternatives, compared to the base condition (WSE).

To allow PDT evaluation of the difference between the 2006 SEIS assumption (lowering the SSM line by one foot) and the assumption for the new round of modeling (draft LOWSM), SFWMM simulations of the updated alternative 1bS2-m (2006 SEIS TSP) with and without LOWSM were provided on the LORSS modeling web page. The updated regulation schedule graphics for Alternative 1bS2-A17.25 and Alternative 1bS2-m, with the draft LOWSM line included, are provided in Figures A-14 and A-15.

6. Modify Low band breakpoints to assume Level 1 pulse release within the bottom one third of the band, Level 2 pulse release within the middle one third of the band, and Level 3 pulse release within the upper one third of the band. The previous modeling of Alternatives 1b, 1bS2, 1bS2-a17.25, 1bS2-m, and 4 included model inputs that resulted in a narrow band for level 3 pulse releases within the Low band; the previous modeling did not modify the Low band breakpoints when the bottom of the intermediate band was lowered from Alternative 1a to Alternative 1b (and all derivatives from Alternative 1b). The LORSS PDT was informed of this inconsistency in an email dated 30 June 2006, and updated modeling to correct the low band breakpoints was provided to the team on the LORSS modeling web page. The operational decision tree for the low band does not specify the level of pulse release within the band (up to Level 3 pulse is allowed), and both modeling approaches do fall within the operational range permitted within the low band. The alternate approach for Alternative 1bS2-m (the 2006 SEIS TSP) was demonstrated to not alter the performance of the TSP, and it was identified that there would be no change to the 2006 SEIS TSP plan.

The WSE simulation, as included in the 2007LORS base condition modeling for LORSS, also includes the even-thirds assumption for pulse releases, and the new round of alternative modeling will include this change for consistency.

Final Alternatives: 2007 LORSS SEIS

Based on consideration of public and agency comments to the 2006 SEIS, three additional alternatives (Alternatives T1, T2, and T3) were developed as TSP refinements during additional plan formulation. The updated simulations for the 2006 SEIS TSP (Alternative 1bS2-m) and the parent of this TSP Alternative (Alternative 1bS2-A17.25) were also carried forward for evaluation within the new round of modeling. The alternative descriptions include a listing of changes to the current LORS, WSE. The WSE regulation schedule divides Lake Okeechobee stages into regulation zones including Zone A, Zone B, Zone C, Zone D (including D1, D2, and D3), and Zone E, and modification to these WSE regulation zones are referenced in the alternative descriptions within this section. Following completion of the 2006 SEIS LORSS modeling and before completion of the new round of modeling, operations staff determined that the new LORSS regulation schedule would modify the terminology from Lake Okeechobee Zones to Lake Okeechobee Operational Bands, as follows: High Lake Management Band (comparable to WSE Zone A), High Band (Zone B), Intermediate Band (Zone C), Low Band (Zone D, including Zones D1, D2, and D3), a Base Flow Band (not included in WSE), and a Beneficial Use Band (Zone E). The regulation schedule graphics and alternative descriptions for Alternatives T1, T2, and T3 include the modified terminology for operational bands.

The five alternative regulation schedules, plus the updated No Action Alternative, evaluated for the TSP refinements during additional plan formulation include the following:

- The updated No Action Alternative: current regulation schedule, WSE, with the addition of temporary forward pumps;
- Updated Alternative 1bS2-A17.25 which is a similar approach to WSE with a general lowering of the top three regulatory release lines, reduced magnitude of maximum discharge decisions in Zone B and Zone C to the SLE, a reshaping of the line representing the divide between Zone D and Zone E, redefinition of some of the WSE meteorological inputs, and the addition of a new regulatory base flow zone for the Caloosahatchee Estuary;
- Updated Alternative 1bS2-m (2006 SEIS TSP) which is similar to Alternative 1bS2-A17.25 but with a lowering of the second and third regulatory release lines and a lowering of the top three regulatory release lines during the late hurricane season from September 15 through November 1;
- Alternative T1 was developed based on recommendations from Lee County and Sanibel to improve Caloosahatchee Estuary performance demonstrated with Alternative 1bS2-A17.25 and Alternative 1bS2-m; Alternative T1 included increased high and intermediate band (same as Zone B and Zone C used in WSE) discharges to the SLE, base flow releases to the SLE, and increased base flow releases to the Caloosahatchee Estuary, but Alternative T1 did not demonstrate significant improvements to the Caloosahatchee Estuary;

- Alternative T2 was developed based on evaluation of Lake Okeechobee Operations Screening (LOOPS) model output to reduce high flows greater than 4500 cfs to the Caloosahatchee Estuary and allow a minor increase in high stages within Lake Okeechobee; Alternative T2 included measuring of all Caloosahatchee Estuary pulse releases at S-79 (instead of S-77), the lowering of the bottom of the pulse band to encourage more low-level regulatory pulse releases, and a base flow to the St Lucie Estuary;
- Alternative T3 was developed from Alternative T2 in an effort to maintain the performance balance of Alternative T2, reduce the magnitude and duration of high lake stages, and further reduce the frequency and duration of undesirable high-volume discharges to the Caloosahatchee Estuary

The three new alternatives for the new round of modeling were developed in an effort to demonstrate potential improvements to the TSP plan based on the following guidance: evaluate the 17.25 feet Lake Okeechobee elevation as a performance measure, not as a constraint; evaluate additional alternatives to reduce the frequency of high flows greater than 4500 cfs to the Caloosahatchee Estuary; evaluate alternatives to obtain an equitable balance between the coastal estuaries; and evaluate alternatives to improve the balance between all system-wide performance measures.

PDT performance evaluation of 2006 SEIS Alternatives 1bS2-A17.25 and 1bS2-m demonstrated similar performance between the two alternatives; the notable difference between the two alternatives is that Alternative 1bS2-A17.25 was modified to demonstrate zero days in the SFWMM POR with Lake Okeechobee stage above 17.25 feet to generate Alternative 1bS2-m. With the guidance to evaluate the 17.25 feet Lake Okeechobee elevation as a performance measure (not as a constraint), the starting point for the three additional alternatives was the updated version of Alternative 1bS2-a17.25. The new alternatives incorporate all assumptions included in the updated simulation of Alternative 1bS2-A17.25, except where changes are noted in the alternative descriptions. Complete details regarding the key components of the regulation schedules for Alternative 1bS2-A17.25 and Alternative 1bS2-m have been previously discussed, as these two alternatives are carried forward from the 2006 SEIS evaluation and only updated to include the most current assumptions and data sets. A brief overview of Alternative 1bS2-A17.25 is provided below in order to clearly convey all of the regulation schedule details that will be included in Alternatives T1, T2, and T3, which were developed from Alternative 1bS2-A17.25.

The naming convention used during the SFWMM modeling in support of the 2007 LORSS SEIS is referenced throughout this appendix. The naming convention for the alternatives was later modified during preparation of the 2007 LORSS SEIS main report, as follows: Alternative A (Alternative 1bS2-A17.25), Alternative B (Alternative 1bS2-m), Alternative C (Alternative T1), Alternative D (Alternative T2), and Alternative E (Alternative T3). The output and performance measure results of the SFWMM simulations are not affected by the modified naming convention, and the two names for an alternative may be used interchangeably.

A. Alternative 1bS2-A17.25 (same as 2006 SEIS alternative)

Alternative 1bS2-A17.25 included the following modifications to the current WSE regulation schedule (2007LORS simulation represents the current WSE regulation schedule with the SFWMD temporary forward pumps, which are also included in all LORSS alternatives):

1. The bottom elevations for the upper three regulatory zones are lowered, resulting in a more pro-active schedule to control high water conditions in Lake Okeechobee; "up to maximum" releases to tidewater are called for if Lake Okeechobee stage exceeds 17.25.
2. The re-shaping of the line representing the divide between Zone D and Zone E.
3. THCs are used that represent longer-term wet or dry conditions that have persisted in the tributaries—PDSI and 14-day mean Lake Okeechobee net inflow.
4. Base flow releases to the Caloosahatchee River Estuary (CRE) of 450 cfs (measured at S-79) are allowed when Lake Okeechobee water levels are within a new base flow zone (Zone D0) or above; the original proposed elevation (original Alternative 1b) for the bottom elevation of Zone D0 was lowered by one foot.
5. Zone B and Zone C discharges to the SLE are reduced: maximum discharge to the SLE under normal to wet THC is reduced from 3500 to 2800 cfs in Zone B and reduced from 2500 to 1800 cfs in Zone C; maximum discharge to the SLE is reduced from 3500 to 2800 cfs in Zone C under very wet THC; maximum discharge to the SLE is reduced from 2500 to 1800 cfs in Zone D under very wet THC. The intention of this modification was to reduce the potential impacts associated with high discharge events to the SLE.

B. Alternative T1

Alternative T1 (TSP modification 1) was proposed by the USACE, Water Management Section. The decision tree, Part 1 (releases to WCAs) for Alternative T1 remains unchanged from Alternative 1bS2-A17.25, and the decision tree with updated terminology is shown in Figure A-15. The decision tree, Part 2 and regulation schedule for Alternative T1 are shown in Figure A-16 and A-17. The following changes were made to Alternative 1bS2-A17.25:

1. Lake Okeechobee late season break points are changed from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address the potential of late season hurricanes.
2. Level 3 pulse measured at S-77 is changed from average daily flow of 3000 cfs to 2800 cfs.
3. A base flow of 350 cfs to the SLE measured at S-80 in low and intermediate bands is included in this alternative.
4. Base flow to the Caloosahatchee Estuary is changed from up to 450 cfs at S-79 to up to 650 cfs measured at S-77 in the low and intermediate bands. It is recognized that discharge at S-79 of up to 800 cfs could be recommended for occasional implementation, but this infrequent recommendation would not be consistent with inclusion for the complete POR modeling; additional flow at S-79 could be delivered by redistribution of the baseflow releases to the SLE.

5. No changes to base flow of 450 cfs measured at S-79 in the base flow band.
6. The bottom of the base flow band is raised by 0.25 feet.
7. Change the High and Intermediate band flow of up to 2800 cfs measured at S-80 back to WSE level of up to 3500 cfs.

C. Alternative T2

Alternative T2 (TSP modification 2) was proposed by the SFWMD, based on screening results from the LOOPS model. The decision tree, Part 1 (releases to WCAs) for Alternative T2 remains unchanged from Alternative 1bS2-A17.25, and the decision tree with updated terminology is shown in Figure A-15. The decision tree, Part 2 and regulation schedule for Alternative T2 are shown in Figures A-18 and A-19. The following changes were made to Alternative 1bS2-a17.25:

1. Zone D0 raised to 12.6 feet to maintain Zone D0 higher than navigation minimum Lake Okeechobee elevation of 12.56 feet.
2. All Caloosahatchee Estuary pulse releases measured at S-79 instead of S-77, in all lake bands when pulse releases are called for, to reduce high flow exceedences caused by lake release plus local C-43 basin runoff.
3. Bottom of Zone D1 lowered by one half foot, to encourage more pulse releases which help reduce steady high-volume discharges.
4. Add a small baseflow of 200 cfs (low volume regulatory discharge) to SLE (below S-80, to include accounting of C-23 and C-24 basin inflows) whenever base flow releases are called for in decision tree. Additional base flow deliveries at S-79 (450 cfs at S-79 is included, per Alternative 1bS2-A17.25) could be delivered by redistribution of the baseflow releases to the SLE.

D. Alternative T3

Alternative T3 (TSP modification 3) was developed through the collaborative efforts of the USACE and SFWMD, following LORSS PDT review of the updated 2006 SEIS alternatives (Alternatives 1bS2-A17.25 and 1bS2-m) and the new T1 and T2 alternatives. The decision tree, Part 1 (releases to WCAs) for Alternative T1 remains unchanged from Alternative 1bS2-A17.25, and the decision tree with updated terminology is shown in Figure A-15. The decision tree, Part 2 and regulation schedule for Alternative T3 are shown in Figure A-20 and A-21. Alternative T3 was developed from Alternative T2, with the following changes:

1. Lake Okeechobee late season break points are changed from September 30 to November 1 for the top of the High, Intermediate, and Low bands to address the potential of late season hurricanes (consistent with Alternative T1).
2. Inclusion of an October 1 breakpoint at 13.0 feet for the bottom of the baseflow zone D0 (consistent with original 2006 SEIS Alternatives 2a and 4), to provide some protection to low lake levels at the end of the wet season.
3. Caloosahatchee Estuary Level 1 pulse level increased from average daily rate of 1600 cfs to 2000 cfs, to allow for increased releases below 2800 cfs to reduce higher lake levels and the associated higher releases.

4. Caloosahatchee Estuary Level 2 pulse level increased from average daily rate of 2300 cfs to 2500 cfs, to allow for increased releases below 2800 cfs to reduce higher lake levels and the associated higher releases.
5. Caloosahatchee Estuary Level 3 pulse level unchanged, at average daily rate of 3000 cfs.
6. Maximum Caloosahatchee Estuary discharges reduced from 4500 cfs to 4000 cfs when the Lake Okeechobee stage is within the intermediate (THC: normal to wet) or low (THC: very wet) bands.

Additional assumptions common to all previous alternatives are next briefly reviewed. All alternatives include the SFWMD temporary forward pumps at S-351, S-352, and S-354 for water supply, as included in the No Action Alternative. The regulation schedules for the WCAs (including WCA-1, WCA-2A, WCA-2B, WCA-3A, and WCA-3B), including environmental water supply deliveries from Lake Okeechobee, are not modified from the No Action Alternative for the LORSS alternatives. For alternatives formulated to include base flow releases to the Caloosahatchee and/or SLEs (measured at S-79 and S-80, respectively) when Lake Okeechobee stages are within an established base flow regulatory band, it is recognized that very dry climate conditions may require that releases to the estuaries be discontinued; this note will be included on the 2007 LORSS, and this consideration is represented in the SFWMM simulations with a 0.50 million acre-feet threshold for the multi-seasonal forecast of Lake Okeechobee inflow (base flow releases are discontinued if the inflow forecast is below this threshold). All alternatives assume backflow from the St. Lucie Canal (C-44) to Lake Okeechobee to be allowed to occur at lake stages of 14.50 feet or 0.25 feet below the bottom of the lowest non-baseflow regulatory zone, whichever is lower. These operations were developed to achieve similar performance as the No Action Alternative, while seeking to avoid frequency oscillation between regulatory releases and backflow at S-308. The No Action Alternative assumes backflow below Lake Okeechobee stages of 14.50 feet, consistent with operations under WSE and always more than 0.25 feet below the lowest regulatory release zone for the WSE regulation schedule. All LORSS alternatives and the No Action Alternative assume backflow from the Caloosahatchee River Canal (C-43) to Lake Okeechobee to be allowed to occur for lake stages below 11.10 feet. Operations for gravity flow from the West Palm Beach Canal and L-8 Canal to Lake Okeechobee are not modified from the No Action Alternative for the LORSS alternatives and remain consistent with existing operations.

Alternative T3 was selected in December 2006 as the recommended plan for the 2007 LORSS SEIS. For the purpose of this appendix, standard performance measure output included from the SFWMM will generally include a summary of all alternatives. For those instances where additional analysis or graphics have been prepared for this appendix, the summary discussion may only include the No Action Alternative and the recommended plan, Alternative T3.

OVERVIEW OF THE SFWMM

Brief description of the SFWMM

The SFWMM is an integrated surface water-groundwater model that was developed and is maintained by the SFWMD. The SFWMM simulates the hydrology and water management of southern Florida from Lake Okeechobee to Florida Bay. The SFWMM spans a region of over 7,600 square miles with a two-mile by two-mile grid (Figure B-1); and simulates the system-wide hydrologic response to daily climatic inputs (rainfall and reference evapotranspiration). Other areas tributary to Lake Okeechobee (e.g., Kissimmee River, C-43 and C-44) are also part of the model, even though they are not explicitly simulated with the four square mile grid cells.

The SFWMM simulates infiltration, percolation, evapotranspiration, surface and groundwater flows, levee underseepage, canal-aquifer interaction, well withdrawals for irrigation and/or public water supply, and current or proposed water management structures (i.e., canals, spillways, reservoirs, pump and wellfields), and current or proposed operational rules (i.e., regulation schedules and water shortage management plans). The SFWMM is not a succession model: that is, it fixes the land use/cover and associated infrastructure for the entire simulation period. Thus the simulations represent the response of a fixed structural and operational scenario, to historical climatic conditions. This provides a very useful means for comparing the effects of alternative structural and/or operational proposals.

The ability to simulate key water shortage policies affecting urban, agricultural, and environmental water supply facilitates the investigation of tradeoffs between different water demands and sub-regions. Two dimensional regional hydrologic processes are simulated at a daily time step using a mesh of (2 x 2 mile) grid cells producing extensive output that can be summarized into numerous performance measures for plan evaluation. The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. The SFWMM (also referred to as the 2x2 model) is the premier hydrologic simulation model used to evaluate regional plans for Everglades' restoration and sustainable development in south Florida. Documentation (SFWMD, 2005) including model calibration, verification and peer review can be viewed at <http://www.sfwmd.gov/org/pld/hsm/models/sfwmm>. Original documentation of the SFWMM was completed in 1984. However, since that time several documentation and peer review efforts have been completed. The documentation and peer review of the model was completed for the current SFWMM version 5.5, in November of 2005. Excerpts from the latest documentation have been included within the report to provide the reader with an introduction to the capabilities of the SFWMM, but the reader should refer to the complete documentation for a complete review of the SFWMM.

Numerical solution

The model uses a daily time step, consistent with the minimum time increment for which input climatic data are available and can be run for time periods ranging from one month to 36 years. A distributed finite difference modeling technique is used to model the gridded portion of the

model domain with two-mile by two-mile square grid cells. Lumped parameter modeling approaches are used for Lake Okeechobee and the northern lake service areas, which include the Caloosahatchee and St. Lucie Basins. Homogeneity of physical and hydrologic characteristics is assumed within each model grid cell. The grid discretization in the SFWMM is sufficiently fine to describe the solution to the overland and groundwater flow equations with reasonable resolution and to minimize numerical errors (Lal, 1998).

A diffusion wave approximation of the full equations for overland flow from cell-to-cell is solved using an Alternating Direction Explicit (ADE) scheme with four six-hour time slices. Groundwater flow is solved using the vertically-averaged, transient groundwater flow equation with a variation of the unconditionally stable and explicit Saul'yev (1964) method. To minimize bias, the numerical formulation is solved in four different directions in four successive time steps.

Groundwater flow beneath levees is simulated using separate regression equations, based on more detailed two-dimensional finite element modeling developed to simulate localized levee under-seepage (SFWMD, 2005). To simulate the canals in the system, and to account for changes of storage in the canal due to inflows and outflows, the SFWMM utilizes a mass balance approach. An iteration scheme solves for the equilibrium canal stage each time step. A backwater profile solution scheme is used each time step for the primary canals in the EAA that are intensively managed by pumping.

Simulation outputs are generally available daily for each canal, structure, and grid cell within the model domain, including existing gage locations. Figure B-2 displays the gage locations readily output by the model, and Figure B-3 displays the simulated canal network in the SFWMM used for the LORSS. Model output is additionally aggregated for pre-defined groups of adjacent grid cells (indicator regions in Figure B-4; additional maps are also available through the Restoration Coordination and Verification (RECOVER) Evaluation Team, at the following web address: http://www.evergladesplan.org/pm/recover/eval_team_maps.cfm) or for larger areas or basins (examples include WCAs and Everglades National Park [ENP]). Transects used for the comparison of overland flow volumes are provided in Figure B-5.

Overview of Lake Okeechobee Management Processes in the SFWMM (SFWMD, 2005)

In the SFWMM, Lake Okeechobee is simulated as a lumped hydrologic system as contrasted to the majority of the model domain where a distributed system of two-mile by two-mile grid cells is used. There is only one water level that is associated with Lake Okeechobee at any given time step. For each daily time step the water budget equation is solved for Lake Okeechobee. This equation relates the change in storage within Lake Okeechobee as a control volume, and incoming and outgoing flows for the same control volume. Mathematically, lake hydrologic components (rainfall, evapotranspiration and seepage) and managed flows (structure discharges) account for changes in lake storage. Net levee seepage and regional groundwater movement in Lake Okeechobee are assumed to be small relative to the other hydrologic components of the lake water budget and are, therefore, not calculated in the model.

Lake Okeechobee water levels are checked against the defined operational zones. Depending on which zone simulated lake stages fall after adjusting for water supply and storage injection discharges, the additional criteria as defined in the decision tree are applied. In the SFWMM, weekly pre-processed time series data is input and user input options define the thresholds for classification of tributary conditions. Climatic and meteorological forecasts consider several longer-term (up to twelve month) regional, global, and solar indicators in helping to estimate the potential volume of water that can be expected to flow into Lake Okeechobee. As with the tributary conditions, information provided by these indices helps to determine when there is an opportunity to 'hedge' water management practices. The decision tree operational guidelines for WSE (and other similar schedules) utilize three different outlooks in the decision making process: meteorologic forecast, seasonal outlook and multi-seasonal outlook. Each of these measures has an associated classification scheme for determining hydrologic regimes. In the SFWMM, monthly pre-processed non-perfect hind-cast data is input and user options define the thresholds for classification of outlooks. An additional simplifying assumption is made in the model in which the meteorologic forecast is not considered and the seasonal forecast is assumed to apply in both decision boxes. This assumption is necessary due to the difficulty in deriving hind-cast meteorologic forecasts over the 1965-2000 period of simulation.

Examining the WSE "Part 2" decision tree outcomes for discharges to tide, considerable flexibility can be observed in the final determination of discharge volumes. Several of the outcome boxes indicate releases "up to" a determined level. In real time operations, this allows water managers to optimize the performance of the competing considerations when making regulatory discharges. In the SFWMM, simplifying assumptions are made that enable users to retain some flexibility in determining the operations associated with the decision tree outcome. For boxes that dictate a release "up to" maximum discharge or a determined steady flow, the model will always simulate the maximum allowable flow rate. In the case of decision boxes that indicate "up to maximum pulse release", users have the option of specifying which of the three levels of pulse discharges to make to both the St Lucie and Caloosahatchee Estuaries. Pulse releases are designed to mimic the flow pattern associated with naturally occurring rainfall events and as such should result in less impact to the estuary ecology by allowing time for recovery of the salinity envelope prior to resuming high discharge rates. Once a ten-day outflow pulse is initiated by the schedule, the release rule is continued to completion even if lake stage drops below that pulse level. After a ten-day period is completed, the need for additional releases is re-evaluated.

SFWMM Version to Be Used

SFWMM v5.5 was used for the LORSS. Version 5.0 and later of the model includes a major effort to upgrade the model including adding an additional five years of climatic data from 1996-2000, updating land-cover for 2000 conditions, reviewing methods to estimate potential evapotranspiration, and updating rainfall data used. Complete documentation is available on the SFWMD webpage for the SFWMM: <http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/> (SFWMD, 2005).

Period of Simulation

The SFWMM produces daily output for a 36-year POR: 1965-2000. Efforts are ongoing by the SFWMD to compile the climatological data needed to extend the SFWMM POR through 2005. The additional information, though desirable, will not be available for the 2007 LORSS SEIS study.

Strengths and Weaknesses of the SFWMM

The major strength of the SFWMM is that it is a regional integrated surface water/groundwater model covering a large portion of south Florida. The model is well-suited to modeling of the hydrologic conditions which characterize south Florida, including the flat terrain, high water table, and high aquifer transmissivity. The SFWMM has been used in the past for project analysis, and the model is familiar to many interested stakeholders. Particular strengths of the SFWMM include:

- a. It is capable of simulating the interdependency between hydrology and management (operations), and among different components of the regional system.
- b. Canal routing, overland flow, unsaturated zone mass balance, two-dimensional single-layer aquifer flow, spatially-distributed rainfall, and evapotranspiration are included in the model.
- c. Hydrologic impacts on agriculture, urban, and environmental areas can be jointly evaluated through the use of comprehensive, post-processed model output.
- d. The SFWMM is a useful tool in evaluating long-term and short-term effects of management decisions. A 36-year POR for rainfall data (1965-2000) can be simulated in a short runtime of less than two hours.
- e. Regional impacts of hydraulic infrastructure changes are readily evaluated with the suite of model output.
- f. Routines are readily available for modifying model output into performance measure sets, useful tools for comparing regional and area-specific performance of several alternatives.
- g. The SFWMM can provide guidance as to where future data collection and additional modeling efforts should proceed. SFWMM can effectively be used as a regional-scale screening tool to help identify locations and particular years when finer-scale analysis may be needed.

The weaknesses of the SFWMM are related mostly to the sub-regional or localized applicability of the model. The two-mile by two-mile grid cells are described by a single average value for all hydrologic characteristics, including land surface elevation, storage coefficient, permeability, infiltration rate, and roughness coefficient.

Other weaknesses or limitations (that would also apply to other similar models) include:

- a. Model scale is too coarse for studies/investigations that require finer detail of local hydrologic response, for example drawdown analyses and localized levee seepage. Subtle gradients in topography (at a scale smaller than two miles) that may have ecological implications cannot be represented in the model. The coarse scale of SFWMM limits but does not discount its utility for quantifying potential flood impacts.

The SFWMM is not appropriate for detailed farm-scale flood analysis but is appropriate for identifying potential regional flooding impacts.

- b. Groundwater equations are simplified under the assumption of two-dimensional flow, such that transmissivity, storage coefficient, recharge, and hydraulic head can be vertically averaged. The model's solution to the general groundwater flow equations represents regional groundwater flow while empirical levee seepage equations are used to solve for levee seepage.
- c. Quality assurance/quality control (QA/QC) of the model output and performance measure sets is difficult due to the regional nature of the model and the resultant size of the performance measure set. This activity usually requires substantial staff time.
- d. Model was calibrated for stage at monitoring points and control structure flow. The model is not calibrated for overland flow. Note however that the state-of-the-art in modeling and data collection do not allow calibration of any regional scale model to overland flow or groundwater flow volumes. In versions of the SFWMM prior to version 5.0, the comparison of simulated versus historical water levels were compared on an end-of-week, not a daily, basis. For SFWMM V5.0 and later, calibration for stage in marsh gages is completed on a daily time step, while canals are evaluated on a weekly basis.
- e. Intended use of the model is to provide long-term planning-type guidance to water managers with regards to making water policy decisions. The SFWMM is not intended to estimate system responses to extreme conditions whose timing may be on the order of hours or even minutes.
- f. Structure operations are subject to a limited degree of operational flexibility given code and input limitations. The inclusion of complex operational rules may not be possible for all structures. Operational rules for a control structure may change from wet season to dry season, but operations must remain constant for the POR simulated.

Parameter Uncertainty within the SFWMM

The following discussion regarding parameter uncertainty, with specific application for SFWMM performance measures, has been excerpted from the draft RECOVER Comprehensive Everglades Restoration Plan (CERP) System-wide Performance Measures report (RECOVER, 2006).

Parameter uncertainty is estimated by running a series of SFWMM simulations using historic flows assigned at major control structures where reliable flow records exist. Parameters are incrementally varied one at a time from the original calibrated parameters to estimate the 90 percent certainty band for each parameter. The compartmentalization of south Florida's hydrologic system by structures and levees presents a unique situation that allows the effects of varying individual parameters within several regional compartments at the same time. The same parameter value is applied everywhere the physical characteristic is the same, restricting the range in which a specific parameter value may be varied without causing major impacts to the calibration of one or more compartment. The effect of compartmentalization is to reduce uncertainty associated with selection of parameter values. The uncertainty of a given model output variable can be represented by the half-width of the 90 percent uncertainty band. The general rule is the narrower the bands, the greater the level of certainty.

The estimate of performance measure uncertainty was made with version 2.4 of the SFWMM. Structural flows were estimated based on operational rules in place at the time of the simulations (1995) for the high and low values recommended from sensitivity analysis. Parameter uncertainty was estimated by comparing water levels measured at a particular site to those simulated with the calibration version (historical flows assigned to major structures) of the SFWMM for the two-by-two mile cell that contains the measurement site. A large portion of the uncertainty that exists in simulated water levels in this analysis is associated with scaling, process aggregation, the location of the gauging site within the cell, and estimates of regional rainfall and evapotranspiration. These types of uncertainty can be reduced by considering 1) regional performance measures that include model output simulated at several cells and 2) relative benefits of system performance measures between an alternative and the base condition or between alternatives. When considering uncertainty of simulated performance measures, it is important to realize that the certainty of meeting individual performance measures depends on the priority that a particular water management objective has relative to other water management objectives. Therefore, simulated performance measure uncertainty associated with the SFWMM is estimated by replacing the historical flows of the calibration version of the model with simulated flows estimated within the operational version of the model and varying the parameters. The same exercise would need to be completed for each alternative as performance measure uncertainty will vary with each alternative. This can require a great deal of effort that may not be practicable when considering the cost-benefit ratios of taking on such a task and considering that other causes of uncertainty outside the modeling realm may be greater than those of the modeling realm. A large portion of uncertainty that exists in estimating performance measures is caused by such factors as natural climate variability, anthropogenic climate change, and sea level rise.

SIMULATION ASSUMPTIONS

Baseline Assumptions

As a result of the current LORSS, a new regulation schedule is expected to be in place by January 2008 (implementation date assumed for the 2006 SEIS was January 2007; implementation date assumed for the 2007 draft SEIS was July 2007). Soon after that time, a new LORSS will be initiated with an expected duration of approximately three years, at which time a new regulation schedule is anticipated for operation with the Acceler8 and CERP Band 1 projects. The baseline assumptions for SFWMM modeling of the No Action Alternative includes the existing water management structures plus those expected to be in place prior to January 2007:

- 2000 land use and associated irrigation demands for the Lower East Coast Service Area (LECSA). The LECSA includes the developed portions of Palm Beach, Broward, and Dade Counties.
- 2000 public water demands at the existing wellfields.
- 2005 water management facilities and associated operating procedures, including Interim Operational Plan (IOP) operations for WCA 3A and South Dade County in the Lower East Coast.
- Current regulation schedules for Kissimmee Chain of Lakes, WCA 1, WCA 2A and WCA 3A, with the WSE regulation schedule for Lake Okeechobee.
- Temporary forward pumps as proposed by the SFWMD for permitted water supply operations, to be available starting in 2007 (the pumps have since been installed by SFWMD). The pump capacities will be 600 cfs at S-351, 400 cfs at S-352, and 400 cfs at S-354. Based on preliminary operational guidance from the SFWMD, the pumps will be simulated to trigger on for water supply demands if the Lake Okeechobee stage falls below 10.2 feet, and the pumps are assumed turned off when the Lake stage recovers to 11.2 feet.
- STA 3/4 treatment capacity of approximately 64,000 acre-feet (average annual) for Lake Okeechobee regulatory releases, assumed based on current nutrient levels in Lake Okeechobee.
- Water supply backpumping to Lake Okeechobee is not included.
- Flood control backpumping to Lake Okeechobee from the EAA is included.

The baseline model (also referenced as the No Action Alternative or LORSS 2007) was developed from the available SFWMM model determined by the LORSS PDT as the closest representation of the existing conditions prior to implementation of the new LORSS. The LORSS baseline model and all alternatives were developed from the SFWMM modeling previously completed by the SFWMD for the 2005 LECRWSP.

The detailed list of assumptions for the 2005 LECRWSP, as used for the LORSS baseline, are included as Attachment E. Attachment E includes documentation of the SFWMM assumptions for climate, topography, land use, land cover, municipal and agricultural water supply (including Lake Okeechobee Service Area (LOSA), Caloosahatchee and S-4 Basins, St. Lucie Basin, the Seminole Brighton Reservation, the Seminole Big Cypress Reservation, the Seminole

Hollywood Reservation, and the EAA), basin runoff calculations for areas not included in the SFWMM internal computation grid (including Kissimmee Basin, Caloosahatchee and S-4 Basin, St. Lucie Basin, and the EAA), and regulation schedules not proposed for modification under the LORSS (including Kissimmee Basin, Holey Land Wildlife Water Management Area (WMA), Rotenberger Wildlife WMA, WCA 1, WCA 2A and 2B, and WCA 3A and 3B). Changes to the assumptions documented in Attachment E are included in description of alternatives (modifications to the LORS) and documentation of updated assumptions (including the draft LOWSM plan), previously provided in this appendix.

The assumed treatment capacity constraint for STA-3/4 is simulated in the SFWMM by restricting the wet and dry season conveyance capacities for the Miami and North New River canals to pass approximately 58,500 acre-feet, average annual during the dry season and 4,700 acre-feet, average annual during the wet season from Lake Okeechobee to the STA-3/4. The simulations of all LORSS baseline modeling and alternatives do not assume unconditional bypass of the STAs if the Lake Okeechobee stage is within the highest zone of the regulation schedule, although the need for STA by-pass operations may need to be operationally considered under certain conditions.

SIMULATION RESULTS: 2007 LORSS SEIS

An enormous amount of output is generated from each SFWMM simulation and post-processed performance measures and indicators. The general performance of each alternative evaluated for the 2007 LORSS SEIS are reviewed and discussed in this section. Selected graphics to illustrate the performance of each alternative are presented in Attachment C, most of which will be referenced in the discussion. Attachment D includes the performance overview and selected graphics for the alternatives evaluated in the 2006 LORSS SEIS, which are included to provide additional background material to the reader. The complete set of performance measure output for all alternatives evaluated under this study is available on the USACE web page for LORS Modeling, at the following web address: <http://hpm.sfrestore.org/loweb/sfwmm/>. SFWMM simulation results for the new round of modeling is available at this web address, while 2006 SEIS simulations are available only by further clicking the link for informational runs from this web address. The 2006 SEIS simulations are not directly comparable to the new round of modeling due to updated model assumptions, more current data sets, and different source code versions, as previously documented in this appendix. This appendix seeks to include the sub-set of SFWMM output tables and performance measure graphics that were regularly utilized and referenced during the LORSS PDT evaluation of alternatives. The appendix does not attempt to include all possible SFWMM model output tables and performance measure graphics.

The best hydrologic performance measures are those which provide a quantitative indication of how well (or poorly) an alternative meets a specific objective. These hydrologic performance measures are useful surrogates for ecosystem benefits and impacts. Although not presented herein, further evaluations of the results from water quality, ecological, and economic perspectives will be performed as part of the LORSS. Because it was not possible to include all seven alternatives (plus the No Action Alternative) into one graphical plot, two plots including the same performance measures are generated and included in this appendix to show the appropriate comparisons. Simulation results for all alternatives, compared to the No Action Alternative, are summarized for the following regions: Lake Okeechobee, Estuaries and Bays (includes Caloosahatchee and St. Lucie estuaries), WCAs and ENP Flows, and Water Supply. Table 2 summarizes the naming convention used to display the performance measures for each 2007 LORSS SEIS alternative, as names are limited to six to eight characters.

TABLE 2: PERFORMANCE MEASURE LABELS FOR ALTERNATIVES

Alternative	PM data label
no action alternative	07LORS
alternative 1bS2-A17.25	1bS2-aL
alternative 1bS2-m	1bS2-mL
alternative T1	1b-T1
alternative T2	1b-T2
alternative T3	1b-T3

to Lake Okeechobee under the SFWMM simulation of Alternative T3, compared to the No Action alternative. Flood control backpumping to Lake Okeechobee from the EAA is included for the No Action alternative and all alternatives; the total volume of flood control backpumping to Lake Okeechobee from S-2 and S-3 does not show any significant difference (very slight reduction) under the SFWMM simulation of Alternative T3, compared to the No Action alternative.

B. Stage Duration Curves: Flood Protection and Navigation

The stage duration curve for Lake Okeechobee is a key indicator of relative alternative performance (Figures C-3 through C-6). All alternatives demonstrate a trend to reduce lake stages by approximately 1.0 to 1.3 feet under normal to wet conditions. Alternatives in the new round of modeling were all developed from alternative 1bS2-A17.25 based on the performance evaluations from the 2006 LORSS SEIS; more significant spread is observed in the range of alternatives previously evaluated for the 2006 SEIS. Peak stages for the No Action Alternative and other alternatives are summarized as follows: 18.53 ft, NGVD for the No Action Alternative; 17.38 ft for Alternative 1bS2-A17.25; 17.21 ft for Alternative 1bS2-m; 17.23 ft for Alternative T1; 17.57 ft for Alternative T2; and 17.33 ft for Alternative T3. Three of the alternatives plus the No Action Alternative show simulated stages above 17.25 ft, NGVD: 348 days for the No Action Alternative; 9 days for Alternative 1bS2-A17.25; 15 days for Alternative T2; and 8 days for Alternative T3 (note: 13,149 days in the SFWMM 36-year POR). Minimizing the frequency of exceedance of the 17.25 feet elevation offers additional protection for public safety and the HHD; this criteria was evaluated as a project performance measure. Extreme high lake stages have also been documented to adversely impact the plant and animal communities, through processes which include the following: physical uprooting of emergent and submerged plants; reduced light levels in the water column due to increased suspended sediment; and littoral zone exposure to increased nutrient levels from the water column. The frequency of occurrence for lake stages above 16.0 feet, 16.5 feet, 17.0 feet, and 17.25 feet are summarized in Figure C-7.

The reduction of extreme high water stages for Lake Okeechobee is accompanied by a general lowering of the lake stage duration curve, and the potential for extreme low lake levels was also considered during the alternative evaluation process. Increased frequency of low water conditions can adversely impact the health of the Lake Okeechobee littoral zone through increased susceptibility to fire and drought conditions, habitat loss, expansion of exotic and invasive vegetation, and oxidation of organic soils. The minimum simulated stages for Lake Okeechobee are summarized as follows: 9.46 feet for the No Action Alternative; 8.86 feet for Alternative 1bS2-A17.25; 8.84 feet for Alternative 1bS2-m; 8.76 feet for Alternative T1; 8.68 feet for Alternative T2; and 8.71 feet for Alternative T3. Increased frequency of low water conditions may also potentially impact recreational and commercial navigation and availability of lake supply for water supply needs. The number of days below 12.56 feet elevation is stated in the following summary: 2876 days for the No Action Alternative; 4839 for Alternative 1bS2-A17.25; 4922 days for Alternative 1bS2-m; 4909 days for Alternative T1; 5156 days for Alternative T2; and 5128 days for Alternative T3. Extended duration of low water conditions in Lake Okeechobee trigger a minimum flows and levels (MFL) violation if stages remain below 11 feet for greater than 80 consecutive days. The number of MFL violations during the 36-year

POR for the alternatives is summarized: five for the No Action Alternative; six for Alternative 1bS2-A17.25; seven for Alternative 1bS2-m; eight for Alternative T1; six for Alternative T2; and six for Alternative T3 (Figures C-8 and C-9).

Over the SFWMM POR from 1965 to 2000, climate conditions varied significantly within the study area. In response to the wide range of climatologic and meteorologic conditions over the POR, Lake Okeechobee stages vary from year to year and seasonally within each year. To provide a graphical illustration of intra-annual Lake Okeechobee stage variability for the 2007 LORSS SEIS recommended plan (Alternative T3), stage exceedance probabilities were computed for each day within the year (36 data points for each day, corresponding to each of the 36 years in the POR). The stage exceedance curves for Alternative T3 provided in Figure C-10 include the following: maximum daily stage, 90 percent exceedance, 75 percent exceedance, median daily stage (same as 50 percent exceedance), mean daily stage (same as average daily stage), 25 percent exceedance, 10 percent exceedance, and minimum daily stage.

C. Lake Okeechobee Ecology: Extreme High Stage, Extreme Low Stage, Stage Envelope

RECOVER is the branch of the CERP responsible for linking science and the tools of science to a set of system-wide planning, evaluation and assessment tasks. The most current (as of March 2006) RECOVER performance measures for Lake Okeechobee extreme low lake stage, Lake Okeechobee extreme high lake stage, and Lake Okeechobee stage envelope were utilized to evaluate the alternatives of the LORSS effort. RECOVER has since developed additional Lake Okeechobee performance measures (unable to be included for this LORSS study) and reviewed the performance measures used for LORSS, with no proposed changes to the evaluation response curves cited in this section. In-depth documentation and rationale for these performance measures is available through the RECOVER performance measure documentation in the draft RECOVER CERP System-wide Performance Measures report (RECOVER, 2006), at the following web address: www.evergladesplan.org/pm/recover/eval_team_perf_measures.cfm. Extreme low and extreme high lake stage are evaluated with response curves. For extreme low lake stage, zero weeks below 10 feet elevation responds to a score of 100, and 540 weeks or greater with stages below 10 feet elevation responds to a worst case situation and a score of zero (15 weeks per year over 36 year simulation period), with scores linearly varied between the two extremes. For extreme high lake stage, zero weeks above 17 feet elevation responds to a score of 100, and 396 weeks or greater with stages above 17 feet responds to the assumed worst case situation and a score of zero (11 weeks per year), with scores linearly varied between the two extremes. The resultant standard scores for extreme low and high lake stage are summarized as follows, with low score followed by high score: 97/81 for the No Action Alternative; 86/99 for Alternative 1bS2-A17.25; 86/99 for Alternative 1bS2-m; 86/99 for Alternative T1; 83/98 for Alternative T2; and 84/99 for Alternative T3.

The stage envelope performance measure similarly documents the benefits of seasonally-variable water levels within the range of 12.5 feet (June-July low) and 15.5 feet (November-January high) on the plant and animal communities of Lake Okeechobee. The conceptualization of the optimal stage envelope seasonal variation is shown in Figure C-11 (the comparison actually utilizes smoothed boundaries for the upper and lower envelope); in simplified terms, penalty points are assigned to each alternative based on deviations outside of the envelope, with increased penalty

points with increased distance away from the optimal envelope. The worst case scenario for variability above the stage envelope is assumed to be one where the lake stage hydrograph is always in the poor zone (one foot outside of the stage envelope), which equates to a total score of 1872 foot-weeks; the response curve is a line between 0 (target, score of 100) and 1872 foot-weeks (score of 0). For deviation of lake stage below the envelope, the target is 192 weeks. This is the score that would be obtained if all years had hydrographs within the optimal zone, except for once per decade the stage falling to just below 11 ft, elevation NGVD for an average of three months. The response curve is a line between 192 (192 foot-weeks or less receives a score of 100) and 1872 foot-weeks (worst case scenario receives a score of zero). The resultant standard scores for lake daily stage (RECOVER performance measure specified weekly stage, but only daily stage comparisons are available within the LORSS evaluation timeframe) above and below the stage envelope are summarized as follows, with the above score followed by the below score: 55/70 for the No Action Alternative; 80/33 for Alternative 1bS2-A17.25; 82/31 for Alternative 1bS2-m; 83/30 for Alternative T1; 81/26 for Alternative T2; and 81/26 for Alternative T3. The percentage of time within the stage envelope was also identified for all alternatives as comparable, ranging within a narrow band from 25 percent (Alternatives T2 and T3) to 28 percent (No Action Alternative) of the 36-year POR. Given the similarity of time within the stage envelope band, additional focus was placed on the deviation of stages when outside the stage envelope band; alternatives observed to most significantly reduce the extreme high water stages for Lake Okeechobee will score better for the stage envelope above and tend to score lower for the stage envelope below.

Estuaries and Bays

One of the objectives for managing Lake Okeechobee levels was to reduce the number of high regulatory discharges to the Caloosahatchee and St. Lucie estuaries. Recognizing the objective to lower the high lake levels, a strategy was incorporated into the alternatives to make more low-level (environmentally friendly) releases to avoid the high-level regulatory releases. Figures C-12 through C-35 are examples of the modeling results as related to the following discussion. All of the figures can be reviewed at: <http://hpm.saj.usace.army.mil/loweb/sfwmm>.

A. Caloosahatchee Estuary

For all the alternatives, the mean monthly flows between 2800 and 4500 cfs were similar, all alternatives showed a reduction of 10 to 13 months compared to the No Action Alternative. For mean monthly flows greater than 4500 cfs, three alternatives showed an increase in the number of events compared to the 29 months of the No Action Alternative: Alternative 1bS2-A17.25 (36 months), the 2006 SEIS TSP Alternative 1bS2-m (35 months), and Alternative T1 (34 months). Two alternatives maintained the performance of the No Action Alternative, consistent with one of the objectives of the TSP revisions for the 2007 SEIS: Alternative T2 and Alternative T3.

In addition to the number of mean monthly flows, the longer durations of high-flow releases (consecutive weeks of seven-day moving average flow >4500 cfs) are of concern for protecting aquatic resources, including juvenile oysters. The base condition (No Action Alternative) shows zero events of six to seven week duration; one event of eight week duration; and two events of 10-12 week duration (28 total weeks of high flows greater than five weeks). All alternatives had

high flows of longer duration than the base. The total number of weeks for events of greater than five week duration is summarized: 88 weeks for Alternative 1bS2-A17.25; 83 weeks for Alternative 1bS2-m, including one event of 13 week duration; 66 weeks for Alternative T1, including one event of 13 week duration; 79 weeks for Alternative T2; and 65 weeks for Alternative T3. During the critical period when many estuarine dependent species reproduce (March–June), the alternatives all show reductions in the number of mean monthly flows greater than 2800 cfs, compared to the base condition.

For the mean monthly flows less than 450 cfs, all the alternatives significantly reduced the number of events: 198 months for the No Action Alternative, 104 months for Alternative 1bS2-A17.25, 105 months for Alternative 1bS2-m, 116 months for Alternative T1, 131 months for Alternative T2, and 131 months for Alternative T3.

Over the SFWMM POR from 1965 to 2000, climate conditions varied significantly within the study area. The average annual regulatory releases from Lake Okeechobee to the Caloosahatchee Canal outlets (S77) have been previously summarized. In response to the wide range of climatologic and meteorologic conditions over the POR, the annual release volumes to the estuary from the combination of Lake Okeechobee and the Caloosahatchee (C-43) Basin varies both annually and seasonally. The annual (1965-2000) and seasonal (January through December) distribution of flows to the Caloosahatchee Estuary, including the contribution from Lake Okeechobee (S-77 outflows) and total flows at the estuary (at S-79, which includes local runoff from the C-43 Basin), are shown in Figures C-16 through C-19 for the No Action Alternative and the 2007 LORSS SEIS recommended plan (Alternative T3).

During the SFWMM POR, the cumulative volume of regulatory releases from Lake Okeechobee to the Caloosahatchee Estuary (S-77) is shown to increase from 13.63 million acre-feet under the No Action Alternative to 14.96 million acre-feet under Alternative T3; the cumulative volume of releases at the Caloosahatchee Estuary (at S-79, including C-43 Basin runoff) is shown to increase from 37.33 million acre-feet under the No Action Alternative to 38.15 million acre feet under Alternative T3. The total contribution percentage of Lake Okeechobee regulatory releases increases from 37 percent in the No Action Alternative to 39 percent in Alternative T3. Annual regulatory releases from Lake Okeechobee (S-77) range from zero to 2.04 million acre-feet (the latter in 1995) in the No Action Alternative; annual regulatory releases from Lake Okeechobee (S-77) range from zero to 2.19 million acre-feet (the latter in 1995) in Alternative T3. To address the question of how frequently specified high flow volumes are discharged from Lake Okeechobee to the Caloosahatchee Estuary, Table 3 provides a summary for the exceedance frequency of specified annual regulatory discharge volumes.

B. St. Lucie Estuary

For all alternatives, the mean monthly flows between 2000 and 3000 cfs were nearly the same or slightly decreased from the base condition: 43 months for the No Action Alternative, 36 months for Alternative 1bS2-A17.25, 38 months for Alternative 1bS2-m, 37 months for Alternative T1, 44 months for Alternative T2, and 42 months for Alternative T3. For mean monthly flows greater than 3000 cfs, all alternatives demonstrate the same or improved performance compared to the base condition: 31 months for the No Action Alternative, 30 months for Alternative 1bS2-

A17.25, 27 months for Alternative 1bS2-m, 28 months for Alternative T1, 31 months for Alternative T2, and 31 months for Alternative T3.

TABLE 3: EXCEEDANCE FREQUENCY FOR ANNUAL LAKE OKEECHOBEE REGULATORY RELEASES TO CALOOSA HATCHETEE ESTUARY (S-77)

Annual LOK Regulatory Release	Frequency for 1965-2000 (years)	
	No Action Alternative	Alternative T3
> 0.00	22	30
> 0.10	17	20
> 0.20	15	20
> 0.30	13	14
> 0.40	12	11
> 0.50	11	11
> 0.60	10	10
> 0.70	9	8
> 0.80	7	7
> 0.90	7	6
> 1.00	4	5
> 1.50	2	1

In addition to the number of mean monthly flows, the longer durations of high-flow releases (consecutive two-week periods with of 14-day moving average flow >3000 cfs) are of concern for protecting aquatic resources, including oysters and submerged aquatic vegetation. The base condition (No Action Alternative) shows 25 total two-week periods of two to three period (four to six weeks) duration; 13 total periods of four to five period (eight to ten weeks) duration; and zero periods of six or greater two-week periods (12 weeks) duration (38 total periods of greater than two-week duration). All alternatives had high flows of longer maximum duration than the base. The total number of two-week periods of greater than two-week duration (one two-week period) are summarized: 35 periods for Alternative 1bS2-A17.25; 34 periods for Alternative 1bS2-m, including one event of eight period duration (16 weeks); 35 periods for Alternative T1; 36 periods for Alternative T2, including one event of eight period duration; and 36 periods for Alternative T3, including one event of eight period duration. During the critical period when many estuarine dependent species reproduce (March–June), the alternatives all show reductions in the number of mean monthly flows greater than 2000 cfs, compared to the base condition.

For the mean monthly flows less than 350 cfs, the minimum flow needs were generally thought to be met by groundwater flows and basin runoff from C-23 and C-24 basins. The three alternatives with base flow releases to the SLE provided slight reduction in the number of months with total estuary mean monthly flows less than 350 cfs: four month reduction with Alternative T1 (base flow measured at S-80), 24 month reduction with Alternative T2 (base flow measured below S-80 in the estuary), and 24 month reduction for Alternative T3 (base flow measured below S-80).

Over the SFWMM POR from 1965 to 2000, climate conditions varied significantly within the study area. The average annual regulatory releases from Lake Okeechobee to the St. Lucie canal outlets (S308) have been previously summarized. In response to the wide range of climatologic and meteorologic conditions over the POR, the annual release volumes to the estuary from the combination of Lake Okeechobee, the St. Lucie Basin (C-44), and local drainage basins downstream of C-44 at S-80 (C-23 and C-24 Basins) varies both annually and seasonally. The annual (1965-2000) and seasonal (January through December) distribution of flows to the SLE, including the contribution from Lake Okeechobee (S-308 outflows) and total flows at the estuary (below S-80, which includes local runoff from the C-44, C-23, and C-24 Basins), are shown in Figures C-24 through C-27 for the No Action Alternative and the 2007 LORSS SEIS recommended plan (Alternative T3).

During the SFWMM POR, the cumulative volume of regulatory releases from Lake Okeechobee to the SLE (S-308) is shown to increase from 5.11 million acre-feet under the No Action Alternative to 5.93 million acre-feet under Alternative T3; the cumulative volume of releases at the SLE (at S-308, including C-44, C-23, C-24 Basin runoff) is shown to increase from 28.42 million acre-feet under the No Action Alternative to 30.23 million acre feet under Alternative T3. The total contribution percentage of Lake Okeechobee regulatory releases increases from 18 percent in the No Action Alternative to 20 percent in Alternative T3. Annual regulatory releases from Lake Okeechobee (S-308) range from zero to 0.78 million acre-feet (the latter in 1995) in the No Action Alternative; annual regulatory releases from Lake Okeechobee (S-308) range from zero to 0.86 million acre-feet (the latter in 1995) in Alternative T3. To address the question of how frequently specified high flow volumes are discharged from Lake Okeechobee to the SLE, Table 4 is provided to provide a summary for the exceedance frequency of specified annual regulatory discharge volumes.

TABLE 4: EXCEEDANCE FREQUENCY FOR ANNUAL LAKE OKEECHOBEE REGULATORY RELEASES TO ST. LUCIE ESTUARY (S-308)

Annual LOK Regulatory Release Volume (millions of acre-feet)	Frequency for 1965-2000 (years)	
	No Action Alternative	Alternative T3
> 0.00	22	30
> 0.05	17	22
> 0.10	12	16
> 0.20	11	11
> 0.30	6	8
> 0.40	5	5
> 0.50	3	3
> 0.60	3	2
> 0.70	2	1
> 0.80	0	1
> 0.90	0	0

C. Lake Worth Lagoon

The RECOVER hydrologic performance measures for the Central Zone of Lake Worth Lagoon are based on the salinity tolerances of oysters. Discharges of 500 cfs or less, quantified with a seven-day moving average, will maintain salinity at or above the 15 part per thousand criteria. To reflect the potential adverse effects of very high discharges (>1000 cfs), a two-day moving average is used. Review of these two performance measures indicates that all alternatives either show slight improvement or equal the base condition (No Action Alternative).

D. Biscayne Bay

Flows to Biscayne Bay were essentially unchanged (± 1 to 2 kAF/yr) in all the alternatives.

E. Whitewater Bay

For all alternatives, there was less than a ± 4 kAF/yr change in overland flow (Transect 21; refer to Figure B-5).

F. Florida Bay

Flows to Florida Bay were unchanged under all alternatives (Transect 23; refer to Figure B-5).

WCA and ENP Flows

The flow changes compared to the No Action Alternative (or base condition), as related to the various alternatives, in the WCAs and ENP are discussed in this section. Generally, the flow changes (as indicated by the transect flows; refer to Figure B-5) in these areas are relatively small. As a result of greater-than-normal lake mixing from recent hurricanes, the assumed STA-3/4 inflow treatment capacity constraint of approximately 63,000 acre-feet/yr reduces the amount of flow from Lake Okeechobee south to WCA 3A; this is because of the increased loading that could occur due to an increased suspension of nutrients in Lake Okeechobee. The STA-3/4 flow constraint is included in all the alternatives as well as in the no action base condition. Figures C-36 through C-69 are examples of the modeling results as related to the following discussion. All of the figures can be reviewed at: <http://hpm.saj.usace.army.mil/loweb/sfwmm>.

A. WCA-1

Average annual flows across Transect T1 show no net change from the No Action Alternative for all alternatives. All alternatives show a slight increase in stage (less than 0.10 feet) in the average to wet portion of the stage duration curve (10-40 percent). Alternative 1bS2-A17.25 and Alternative 1bS2-m generally show a slight increase in stage throughout the full POR. This trend is observed throughout WCA-1, including indicator regions 100 (north), 101 (central) and 102 (south). The No Action Alternative and all LORSS alternatives operate consistent with actual operations to route local basin runoff (C-51 basin) to STA-1E, while passing Lake Okeechobee releases (made to the L-8 canal) and L-8 local basin runoff to tide via S-155A, S-155, S-140, and S-141. Increased regulatory releases from Lake Okeechobee to the L-8 canal

under the alternatives may result in increased need for flood control pumping from the C-51 basin to STA-1E, with an associated minor increase in STA-1E flow through volume and WCA-1 stage downstream of the STA.

B. WCA-2A and WCA-2B

Flows across Transect T2 show some variation in the alternatives. Alternative 1bS2-A17.25, Alternative 1bS2-m, and Alternative T1 show an increase of 4-7 kAF/yr; Alternative T2 shows a slight increase of 2 kAF/yr, and Alternative T3 shows no net increase or decrease in average annual flows compared to the No Action Alternative. No significant differences in the stage duration curves for WCA-2A (Indicator Region 111 figure is provided) are observed between the alternatives and the No Action Alternative. A slight increase in stage (less than 0.1 feet) is observed for the average to dry portion of the stage duration curve for WCA-2B for Indicator Regions 112 and 113.

C. WCA-3A and WCA-3B

Average annual flows across northern WCA-3A (Transect 6) show no net change from the No Action Alternative for all alternatives. Average annual flows across central WCA 3A (Transects T7 and T8) show slight variations between alternatives. For Transect 7, no net change in average annual flows is observed for Alternative 1bS2-A17.25 and Alternative 1bS2-m, and a slight reduction (1-2 kAF/yr) in average annual flows is observed for Alternatives T1, T2, and T3. For Transect 8, a minor reduction of average annual flows (1 kAF/yr) is observed for all alternatives. No significant differences in the stage duration curves for WCA-3A are observed between the alternatives and the No Action Alternative, based on inspection of Indicator Region 118, 123, and 124. Indicator Region 14 from the CERP Restudy (generally slightly south of the current Indicator Region 124 for southern WCA-3A) also shows no significant differences.

Review of the high and low depth criteria for Indicator Region 124 in southern WCA-3A shows the high water depth criteria (weeks with depth greater than 2.5 feet) to be increased from the No Action Alternative by five to six weeks for Alternative 1bS2-A17.25 and Alternative 1bS2-m. No change to the high water weeks are observed for Alternative T1 (404 weeks), and a reduction of high water weeks by four to five weeks are observed for Alternative T2 and Alternative T3. Indicator Region 14 from the CERP Restudy also shows a similar trend for the alternatives.

The assumed treatment capacity constraint for STA-3/4 is simulated in the SFWMM by restricting the wet and dry season conveyance capacities for the Miami and North New River canals to pass approximately 58,500 acre-feet, average annual during the dry season and 4,700 acre-feet, average annual during the wet season from Lake Okeechobee to the STA-3/4. Due to the SFWMM limitations for the modeling of this constraint, all alternatives are shown to send slightly less water south from Lake Okeechobee to STA-3/4 than the No Action Alternative, which is manifested as a slight reduction in average annual overland flow volumes south of STA-3/4. In actual operations, the treatment capacity constraint for STA-3/4 would be an annual constant for the No Action Alternative and all alternatives, and the volume and timing of releases south would not be expected to change.

Minimal differences in the stage duration curves for northern WCA-3B (Indicator Region 125) and western WCA-3B (Indicator Region 126) are observed for the alternatives compared to the No Action Alternative. Review of the stage duration curve for eastern WCA-3B (Indicator Region 128) shows that the LORSS alternatives are slightly higher (less than 0.1 feet) under average to dry conditions and slightly lower (less than 0.15 feet) under extreme dry conditions. The stage reduction in eastern WCA-3B is influenced by the reduced availability of Lake Okeechobee water for Lower East Coast water supply needs during the extreme dry conditions, times at which the Lake Okeechobee stage is lower under the alternative regulation schedules than under the No Action Alternative. Review of the low water criteria for eastern WCA-3B shows an increase in weeks with water depths greater than one foot below ground surface for all alternatives (No Action Alternative includes 69 weeks) of 12 (Alternative T1) to 16 weeks (Alternative T3).

D. ENP

Overland flows into ENP are shown as Transects T17 and T18. Average annual flows across Transect 17 (western Shark Slough) are unchanged or slightly increased for Alternative 1bS2-A17.25 and Alternative 1bS2-m; average annual flows across Transect 17 are slightly reduced by less than one percent for Alternatives T1, T2, and T3 (1-6 kAF/yr). Average annual flows across Transect 18 (eastern Shark Slough) are slightly increased by 2-3 kAF/yr for all alternatives.

Water Supply

All alternatives evaluated, including the No Action Alternative, assume operation of the SFWMD temporary forward pumps for water supply at S-354 (400 cfs), S-351 (600 cfs), and S-352 (400 cfs). Based on preliminary operational guidance from the SFWMD, the pumps are simulated to trigger on for water supply demands if Lake Okeechobee stage falls below 10.2 feet; the pumps are assumed triggered off when Lake Okeechobee stage recovers to 11.2 feet. The No Action Alternative assumes the existing SSM line (set by the SFWMD) to be in place. Based on guidance received from the SFWMD during the LORSS plan formulation process, an updated water shortage management plan (including modified SSM line and operations) is anticipated to be implemented in advance of any new regulation schedule resultant from LORSS.

All alternatives evaluated for the 2006 SEIS assumed a one foot lowering of the existing SSM line as a surrogate for the anticipated water shortage management plan changes by the SFWMD (this assumption was based on a recommendation from the SFWMD). During the additional plan formulation period for consideration of TSP refinements, the operational details of the draft LOWSM plan were provided to the LORSS PDT by the SFWMD (refer to Appendix G, Attachment 1). In order to ensure that the 2007 SEIS LORSS alternatives are evaluated with the best available data for this new SSM plan (name changed to LOWSM) and based on a request from the SFWMD (official comment letter following review of the 2006 draft LORSS SEIS), the decision was made to incorporate the SFWMD draft LOWSM plan into the new round of modeling (including the updates for 2006 SEIS Alternatives 1bS2-A17.25 and 1bS2-m, and the three new 2007 LORSS Alternatives T1, T2, and T3). Based on guidance from SFWMD during the LORSS plan formulation process, the September 2006 draft LOWSM plan was not anticipated to undergo significant change prior to approval by the SFWMD Governing Board

later in 2007; the draft LOWSM plan was therefore incorporated into the SFWMM simulations for the 2007 LORSS SEIS alternatives. It is recognized that the draft LOWSM plan assumed for the 2007 LORSS SEIS evaluation of alternatives is subject to change; SFWMD modifications to the draft LOWSM may change the anticipated water supply performance, compared to the impacts reported and evaluated for the LORSS alternatives in the 2007 LORSS SEIS. The evaluations were conducted by using the best available data at the time of alternative modeling (SFWMD and USACE concurred that the draft LOWSM plan represented a more likely scenario than either the current SSM or the one-foot lowering surrogate previously assumed for the 2006 LORSS SEIS), and all alternatives were evaluated relative to each other with the same LOWSM assumptions in place. The September 2006 draft LOWSM plan lowers the existing SSM line by 0.80 feet (cutbacks start at lower Lake Okeechobee stages), and includes modified lake stage criteria for the varied cutback percentages below the LOWSM line. Information received from SFWMD following the completion of LORSS modeling and release of the 2007 draft LORSS SEIS indicate that the LOWSM water shortage management plan is not expected to be adopted as previously anticipated. Additional documentation is provided in sections 2.3 and 4.4 and Appendix G of the SEIS report.

The No Action Alternative is the only alternative to utilize the existing SSM line. In order to provide additional data related to the assumed lowering of the SSM line and modified cutback rules, a sensitivity model run was completed for the 2007 SEIS recommended plan alternative (Alternative T3) with the existing SSM rules to replace the September 2006 draft LOWSM plan assumed for all LORSS alternatives. A brief discussion of selected water supply performance measures for this sensitivity run set is provided in this water supply performance section. Figures C-86 through C-93 are examples of the modeling results for the discussion of this SSM sensitivity simulation. All of the figures can be reviewed at:

http://hpm.saj.usace.army.mil/loweb/sfwmm/info_runs.

Several performance measures are presented to compare the potential water supply impacts of the alternatives. Particular emphasis is given to water supply impacts under the most significant drought conditions experienced within the simulation POR, as water supply needs under drought conditions are highly susceptible to the observed lowering of Lake Okeechobee stages under the alternatives. Figures C-70 through C-93 are examples of the modeling results as related to the following discussion of SFWMM water supply performance measures. All of the figures can be reviewed at: <http://hpm.saj.usace.army.mil/loweb/sfwmm>.

A. Everglades Agricultural Area

Simulated water supply effects to the EAA are shown based on the performance measure for mean annual EAA Supplemental Irrigation, demands and demands not met. The alternatives are ranked in order of the mean annual volume of demands not met during the 1965-2000 POR: 22,000 acre-feet of demand not met for Alternative T2 (6% of total demand is not met); 21,000 acre-feet for the No Action Alternative and Alternative T3 (6% not met); 20,000 acre-feet for Alternative 1bS2-m (6% not met); and 19,000 acre-feet for Alternative 1bS2-A17.25 and Alternative T1 (5% not met). The alternatives are ranked in order of the mean annual volume of demands not met during the drought years of 1971, 1975, 1981, 1985, and 1989, with increased demand not met indicative of higher potential impacts to EAA water supply: 57,000 acre-feet of

demand not met for Alternative 1bS2-A17.25 (11% of total demand is not met); 58,000 acre-feet for Alternative 1bS2-m (11% not met); 57,000 acre-feet for Alternative T1 (13% not met); 58,000 acre-feet for Alternative T3 (13% not met); 59,000 acre-feet for Alternative T2 (13% not met); and 61,000 acre-feet for the No Action Alternative. All alternatives show reduced water supply impacts to the EAA during severe drought conditions. Reported percentages for demands not met are rounded to the nearest percent.

B. Lake Okeechobee Service Area

Simulated water supply effects to the LOSA are shown based on the performance measure for mean annual LOSA Supplemental Irrigation, demands and demands not met. The alternatives are ranked in order of the mean annual volume of demands not met during the 1965-2000 POR: 9,000 acre-feet of demand not met for the No Action Alternative (4% of total demand is not met); 8,000 acre-feet for Alternative T2 and Alternative T3 (3% not met); and 7,000 acre-feet for Alternative 1bS2-A17.25, Alternative 1bS2-m, and Alternative T1 (3% not met). The alternatives are ranked in order of the mean annual volume of demands not met during the drought years of 1971, 1975, 1981, 1985, and 1989, with increased demands not met indicative of higher potential impacts to LOSA water supply: 20,000 acre-feet of demand not met for Alternative 1bS2-A17.25 (6% of total demand is not met); 21,000 acre-feet for Alternative 1bS2-m, Alternative T1, Alternative T2, and Alternative T3 (6% not met); and 26,000 acre-feet for the No Action Alternative. All alternatives show reduced water supply impacts to the LOSA for overall performance and severe drought conditions. Reported percentages for demands not met are rounded to the nearest percent. Performance measure graphics for Water Year LOSA demand cutback volumes for the seven drought years with the most significant cutbacks are additionally provided (Figures C-74 and C-75).

C. Lower East Coast

Simulated water supply effects to the Lower East Coast are shown based on the number of months of water supply cutbacks for the 36-year POR. The performance measure graphics selected show the number of months under cutback (all cutbacks are phase 1 cutbacks for the LORSS Alternatives) for each of the following LECSA: Northern Palm Beach County, LECSA1, LECSA2, and LECSA3. Phase 1 cutbacks can be induced by one of three triggers: Lake stage in SSM Zone (indicated by upper label on the figures C-80 and C-81), local trigger well stages (lower data label; as expected, this changes minimally for the regulation schedule alternatives), or dry season criteria (indicated by the middle data label; phase 1 restrictions remain in place until the end of the dry season if water restrictions from the Lake or local groundwater triggers occurred anytime during the dry season). For LECSA Northern Palm Beach County, the No Action Alternative shows 38 months of simulated cutbacks; slight increases to 39 months are observed in the simulation results for Alternatives T1 and T2; reduction of cutback months are observed with 33 months under cutback for the Alternatives 1bS2-A17.25, 1bS2-m, and T1. The same trend is observed in the simulation results for LECSA1, LECSA2, and LECSA3. The No Action Alternative simulation results show 38 cutback months for LECSA1, 87 cutback months for LECSA2, and 38 cutback months for LECSA3. Alternatives T2 and T3 show slight increases to 39 cutback months for LECSA1, 88 cutback months for LECSA2, and 39 cutback months for LECSA3. Alternatives 1bS2-A17.25,

1bS2-m, and T1 show a reduction to 33 cutback months for LECSA1, 82 cutback months for LECSA2, and 33 cutback months in LECSA3. Compared to the No Action Alternative, all alternatives show a reduced availability of Lake Okeechobee water for Lower East Coast water supply needs during extreme dry conditions when the Lake Okeechobee stage is lower under the alternative regulation schedules than under the No Action Alternative (Figures C-76 through C-79).

D. Seminole Tribe Reservations: Brighton and Big Cypress

Simulated water supply effects on the Brighton and Big Cypress Seminole Tribe Reservations are summarized for the percent of water supply demand not met, based on SFWMM performance measure graphics shown in Figures C-82 through C-85. Unmet demand for the Brighton Reservation is summarized as follows: 3.5 percent for the No Action Alternative; 2.0 percent for Alternative 1bS2-A17.25; 2.1 percent for Alternative 1bS2-m; 2.1 percent for Alternative T1; 2.4 percent for Alternative T2; and 2.4 percent for Alternative T3. Unmet demand for the Big Cypress Reservation is summarized as follows: 4.6 percent for the No Action Alternative; 7.1 percent for Alternative 1bS2-A17.25; 7.3 percent for Alternative 1bS2-m; 7.1 percent for Alternative T1; 7.7 percent for Alternative T2; and 7.6 percent for Alternative T3.

The SFWMM operations for the water supply delivery to the Seminole Reservations, including assumed structures and operational triggers, were not modified for the LORSS simulations. It is recognized that modifications or improvements to the water supply delivery network may be necessary to continue to provide water supply deliveries per Tribal agreements with the state. Modifications to improve existing canal conveyance, addition of new pump structures, and modified structure operations are not easily accomplished within the SFWMM, and modifications to the existing configuration were not included in the LORSS simulations for the No Action Alternative base condition or other LORSS alternatives.

E. SSM Assumption and Sensitivity Simulation

The general overview of water supply performance measure trends is dependent on the assumption for the SSM line and water shortage management plan operations. As previously summarized, modified SSM line and operations were anticipated to be implemented in advance of any new regulation schedule resultant from LORSS. All alternatives (with the exception of the No Action baseline alternative) assumed the operational details of the September 2006 SFWMD draft LOWSM to be in place, in order to ensure that the 2007 SEIS LORSS alternatives were evaluated with the best available data, at the time of LORSS plan formulation, for this new water shortage management plan. It is recognized that the draft LOWSM plan assumed for the 2007 LORSS SEIS evaluation of alternatives is subject to change; SFWMD modifications to the draft LOWSM may change the anticipated water supply performance, compared to the impacts reported and evaluated for the LORSS alternatives in the 2007 LORSS SEIS.

Generally, the inclusion of the temporary forward pumps allows for the assumption of the lowered SSM (or similar LOWSM) line, meaning that water supply restrictions would be initiated at lower lake stages than currently in practice. To bracket the potential worst case

scenario for water supply impacts that could be associated with future modification of the draft LOWSM (or a similar modified water shortage management plan) plan by the SFWMD, additional data is available for the evaluation of the 2007 LORSS SEIS recommended plan (Alternative T3) through a sensitivity model simulation with the existing SSM line assumed in place (consistent with the No Action Alternative). The assumed LOWSM operations does alter the performance of the Preferred Alternative, as shown in Figures C-86 through C-93. With the existing SSM line assumed in place with the operational rules and regulation schedule of Alternative T3, the simulation results show mean annual EAA supplemental demands not met to increase from an average annual volume of 21,000 acre-feet and average drought year (1971, 1975, 1981, 1985, and 1989) volume of 58,000 acre-feet under Alternative T3 to an average annual volume of 55,000 acre-feet and average drought year volume of 167,000 acre-feet; the percentage of demands not met for the EAA is increased from six to 15 percent for the average year and 13 to 33 percent during the drought years. With the existing SSM line assumed in place with the operational rules and regulation schedule of Alternative T3, the simulation results show mean annual LOSA supplemental demands not met to increase from an average annual volume of 8,000 acre-feet and average drought year volume of 21,000 acre-feet under Alternative T3 to an average annual volume of 23,000 acre-feet and average drought year volume of 58,000 acre-feet; the percentage of demands not met for the LOSA is increased from three to ten percent for the average year and six to 17 percent during the drought years. The number of months of simulated water supply cutbacks for the four LECSAs also show increased cutback months for the 2007 LORSS SEIS recommended plan without the assumption of LOWSM operations: 39 to 49 months for Northern Palm Beach County; 39 to 49 months for LECSA1; 88 to 95 months for LECSA2; and 39 to 49 months for LECSA3. The inclusion of the LOWSM operations with Alternative T3 reduces the number of MFL violations for Lake Okeechobee from seven events with the existing SSM line assumed in place to six events. Both simulations experience MFL conditions during seven individual years within the POR, but Alternative T3 with LOWSM simulation does not show a stage recovery above 11 feet during the 1981-1982 drought period. Alternative T3 with existing SSM shows the stage to briefly rise above 11 feet, before dropping below 11 feet for another MFL violation (counting as two MFL violations for 1981-1982, compared to only one with LOWSM assumed in place). For the six MFL violation periods common to both simulations (assuming the 1981-1982 total days below 11 feet as a single event for the SSM simulation), Alternative T3 with LOWSM shows an increase in average MFL duration by approximately 18 percent compared to Alternative T3 with existing SSM. Additional performance measure graphics, consistent with the performance measures presented for the water supply performance review, are provided in Attachment C.

Alternative T3 with SSM does not change the Lake Okeechobee stage duration curve during wet and average conditions (upper 60% of the stage duration curve), compared the Alternative T3 with SSM. The increased water supply user cutbacks under Alternative T3 with SSM maintain Lake Okeechobee stages up to 0.50 feet higher than Alternative T3 with LOWSM during drier periods of the period of record. Alternative T3 with SSM does demonstrate a small increase in average annual regulatory discharge to the Caloosahatchee (2.7 percent increase), St. Lucie (3.4 percent increase), and L-8 (4.0 percent increase) regulatory outlets from Lake Okeechobee. The increased flows can trigger additional high volume discharges to the estuaries, but the monthly flow distribution is not significantly changed from the Alternative T3 with LOWSM recommended plan simulation, noting that flows of comparable volumes may tend to fall on

either side of the performance measure criteria (2800 or 4500 cfs for the Caloosahatchee Estuary, 2000 or 3000 cfs for the St. Lucie Estuary).

Select performance measures have been summarized; the complete performance measure set is available on the USACE LORSS study web page previously cited (the performance measure set includes “alt1bS2-T3-exSSM” in the title and the abbreviation of “T3exSSM” on the performance measure set graphics). The SSM Line is set by the SFWMD, at elevations below the Lake Okeechobee regulation schedule zones established by the USACE. Modified SSM rules and a modified SSM line are under development by the SFWMD; a draft version of the LOWSM plan has been provided by the SFWMD and included in the LORSS alternative evaluation as a representation of best available data for the LORSS study timeframe. The final SFWMD efforts are anticipated to be completed prior to implementation of any new regulatory schedule for Lake Okeechobee, and the efforts will be able to consider the additional data provided from the 2007 LORSS SEIS recommended plan. The water supply effects of the alternatives, as shown by a review of the performance measures, must be evaluated with consideration of this parallel and ongoing effort by the SFWMD. The performance measure output is dependent on the SSM (or LOWSM) line and rule assumptions; modification of the LOWSM line or draft LOWSM rules (as assumed in place under all alternatives evaluated) will affect the simulated performance, and the nature of the LOWSM changes (changes to the September 2006 SFWMD draft LOWSM plan) will determine the significance of the potential observed improvement or potential additional impact seen in the simulation results. It is anticipated that the SFWMD will provide a summary of performance changes to the 2007 LORSS SEIS recommended plan evaluation based on the final LOWSM plan, compared to the September 2006 draft LOWSM plan previously provided by SFWMD and assumed in place for the 2007 LORSS SEIS alternative evaluation SFWMM simulations. Information received from SFWMD following the completion of LORSS modeling and release of the 2007 draft LORSS SEIS indicate that the LOWSM water shortage management plan is not expected to be adopted as previously anticipated. Additional documentation is provided in sections 2.3 and 4.4 and Appendix G of the SEIS report.

Lower East Coast Stage Levels

Stage duration curves for SFWMM grid cells in the urban and agricultural areas of the Lower East Coast are provided in Figures C-94 through C-111. No significant differences are noted compared to the No Action Alternative.

Additional Information from LOOPS Model for 2001-2005 period:

The SFWMM produces daily output for a 36-year POR: 1965-2000. It is recognized that additional data could be provided from an extended POR. The 36-year POR includes a wide range of climatologic and meteorologic conditions. All alternatives are evaluated for this common POR and compared to the No Action Alternative.

Efforts to extend the SFWMM POR are ongoing by the SFWMD, but the additional POR is not available for the 2007 LORSS SEIS study. The SFWMM is a regional-scale computer model that simulates the hydrology and the management of the water resources system from Lake

Okeechobee to Florida Bay, and the SFWMM remains the best available tool for performing a comprehensive evaluation.

The LOOPS model is a simple mathematical model of the hydrology and operations of Lake Okeechobee and its primary outlets, developed by the SFWMD on the platform of Microsoft Excel® spreadsheet software. Analysts can use the LOOPS model to test a broad variety of operating strategies and receive instant feedback showing the performance for the primary lake-management objectives. LOOPS is not intended to replace the more comprehensive SFWMM; rather it is a screening tool that can help design schedules for further, more in-depth, analysis via the SFWMM. LOOPS is based on similar algorithms as the SFWMM, but its domain is limited to Lake Okeechobee and its tributaries.

To provide additional information for the expected performance of the recommended plan (Alternative T3) for the 2001 through 2005 POR, LOOPS simulations were conducted by the SFWMD during December of 2005 for the No Action Alternative and Alternative T3. For informational purposes, a brief summary of the hydrologic output is provided.

The LOOPS simulations for the No Action Alternative and Alternative T3 are assumed to be extensions of the SFWMM POR, and the starting Lake Okeechobee stage for the 2001 through 2005 LOOPS simulations were extracted from the end of the POR for the SFWMM simulations (December 31, 2000). The Alternative T3 simulation shows a reduction in peak Lake Okeechobee stage from 17.95 in the No Action Alternative to 17.01, with the number of days above the 17.25 feet performance measure reduced from 84 days to 0 days. A similar reduction in minimum Lake Okeechobee stage is also observed, with stages lowered from 9.95 with the No Action Alternative to 8.01 with Alternative T3. The number of months with average discharge to the Caloosahatchee Estuary greater than 2800 cfs is reduced from 25 months (out of 60 months during 2001-2005) to 22 months under Alternative T3, with an increase of two months with average flows greater than 4500 cfs (13 to 15 months). The number of months with average discharge to the SLE greater than 2000 cfs is increased from 18 to 21 months with Alternative T3, with no change in the number of months with average flows greater than 3000 cfs. To evaluate the sensitivity of 2001-2005 Lake Okeechobee stage to the assumed initial stage condition, a LOOPS simulation was also completed with the No Action Alternative and Alternative T3 starting from the historical Lake Okeechobee stage on January 1, 2001 (11.11 feet). Stage hydrographs for Lake Okeechobee 2001-2005 from the two LOOPS simulations are provided as Figure C-112 and Figure C-113.

SUMMARY

The No Action Alternative, along with five other alternatives, were modeled using the SFWMM. The modeling intent and differences of the alternatives were presented. Model output and post-processed products were used in the selection of the 2007 LORSS SEIS recommended plan, Alternative T3. Selected examples of the model output and performance measures are included as attachment C (Figures C-1 through C-113).

REFERENCES

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- Saul'yev V.K. 1964. *Integration of Equations of Parabolic Type by the Methods of Nets*. New York, New York: Pergamon Press.
- South Florida Water Management District (SFWMD) and the Interagency Modeling Center. November 2005. Final Documentation for the SFWMM (v5.5). South Florida Water Management District, West Palm Beach, Florida.

ATTACHMENT A
Regulation Schedule Figures for LORSS Alternatives Evaluated

/OKEECHOBEE/BASE FLOW ZONE/ELEV-REG/01JAN1960/IR-DECADE/LORS-FWO/

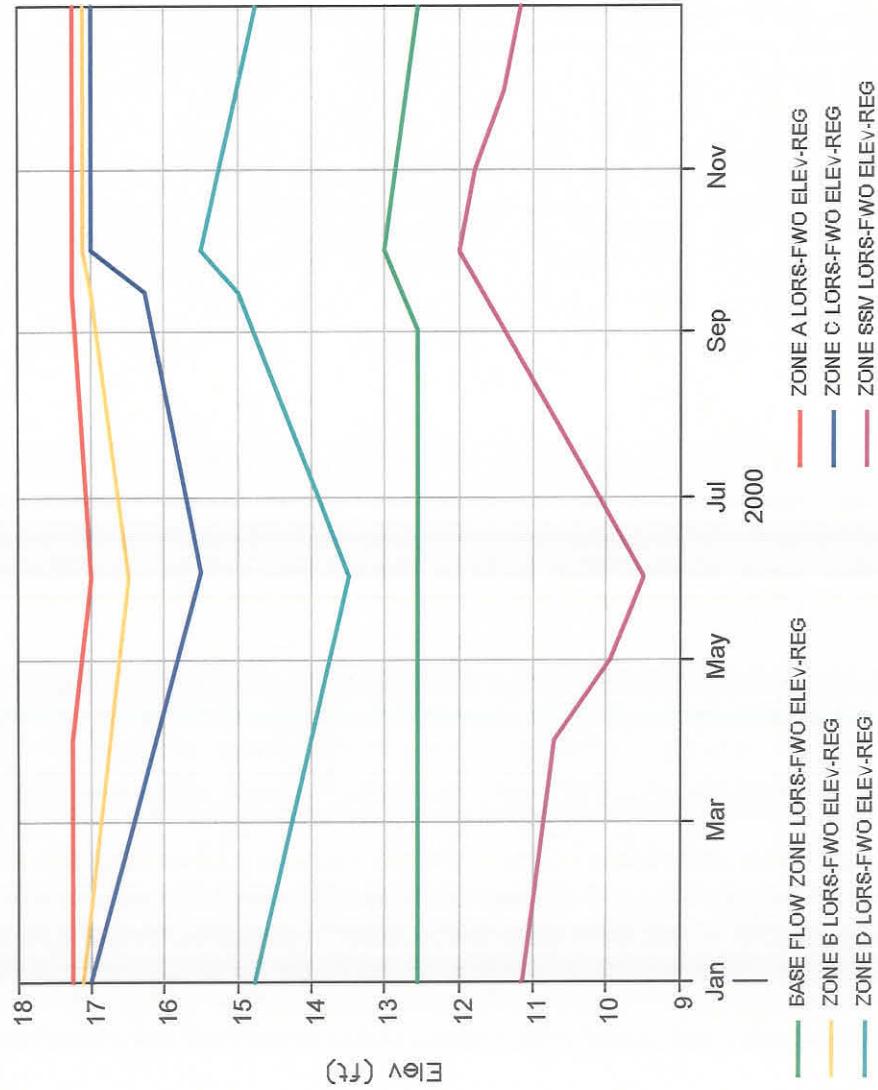


FIGURE A-1: REGULATION SCHEDULE FOR ALTERNATIVE LORS-FWO

/OKEECHOBEE/ZONE A/ELEV-REG/01JAN1960/IR-DECADE/ALTIBS2-A17.25/

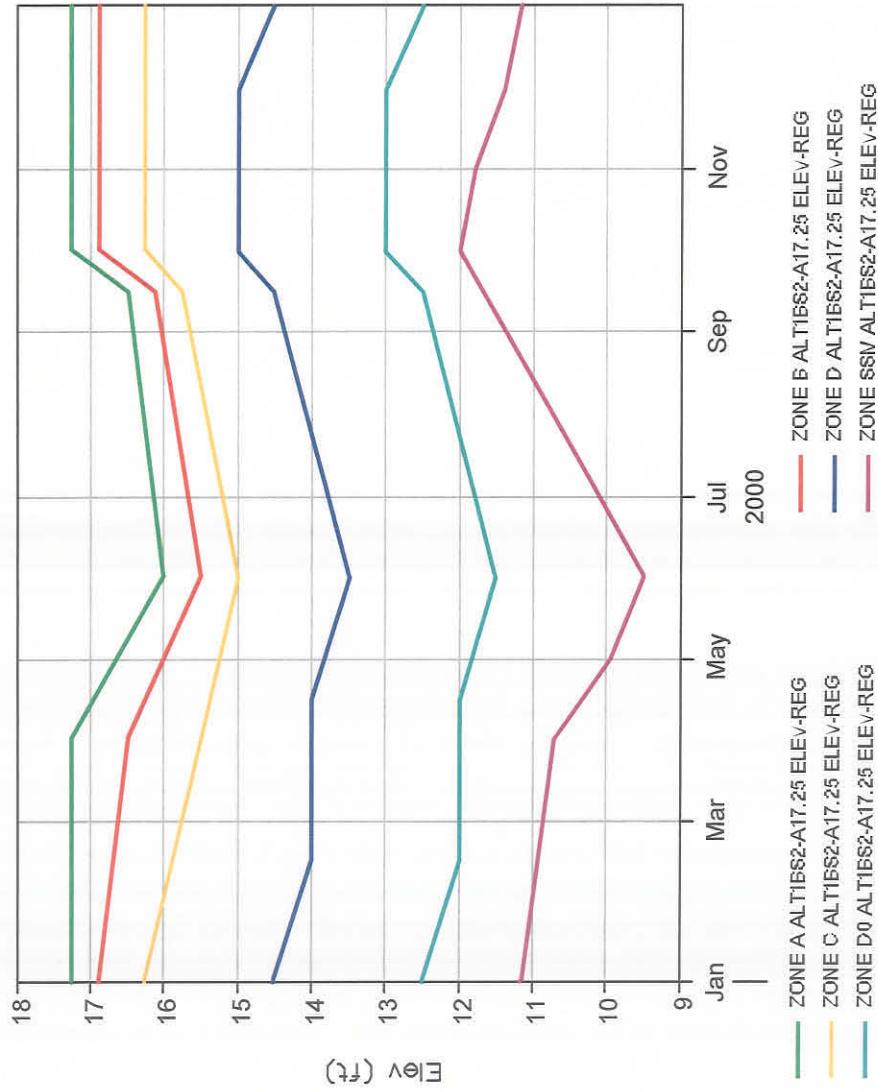


FIGURE A-2: REGULATION SCHEDULE FOR ALTERNATIVE 1BS2-A17.25 (2006 SEIS)

WSE Operational Guidelines Decision Tree

Part 1: Define Lake Okeechobee Discharges to the Water Conservation Areas

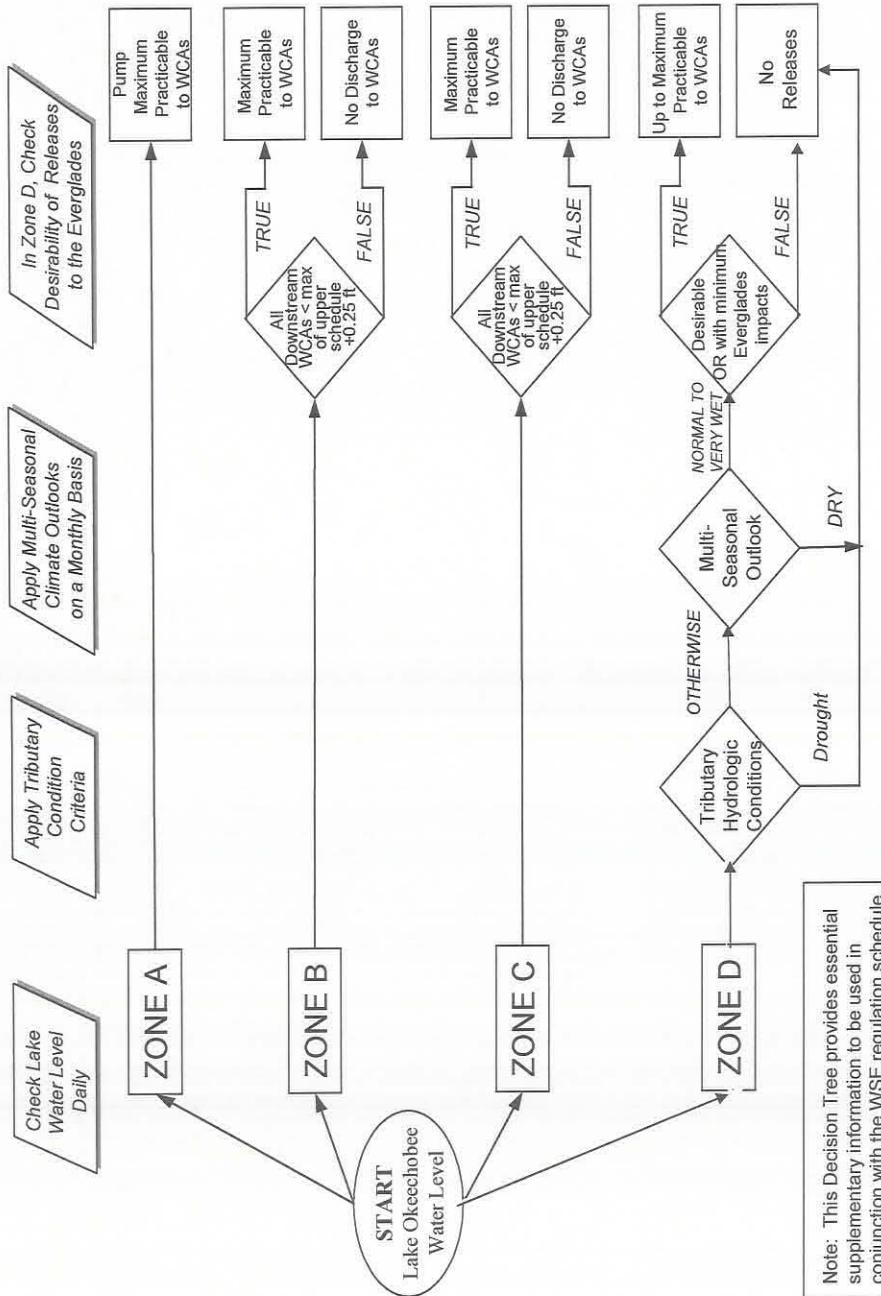


FIGURE A-3: DECISION TREE, PART 1 FOR ALTERNATIVE 1BS2-A17.25, ALTERNATIVE 1BS2-M, AND ALTERNATIVE 4-A17.25

Note: This Decision Tree provides essential supplementary information to be used in conjunction with the WSE regulation schedule.

WSE Operational Guidelines Decision Tree

Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)

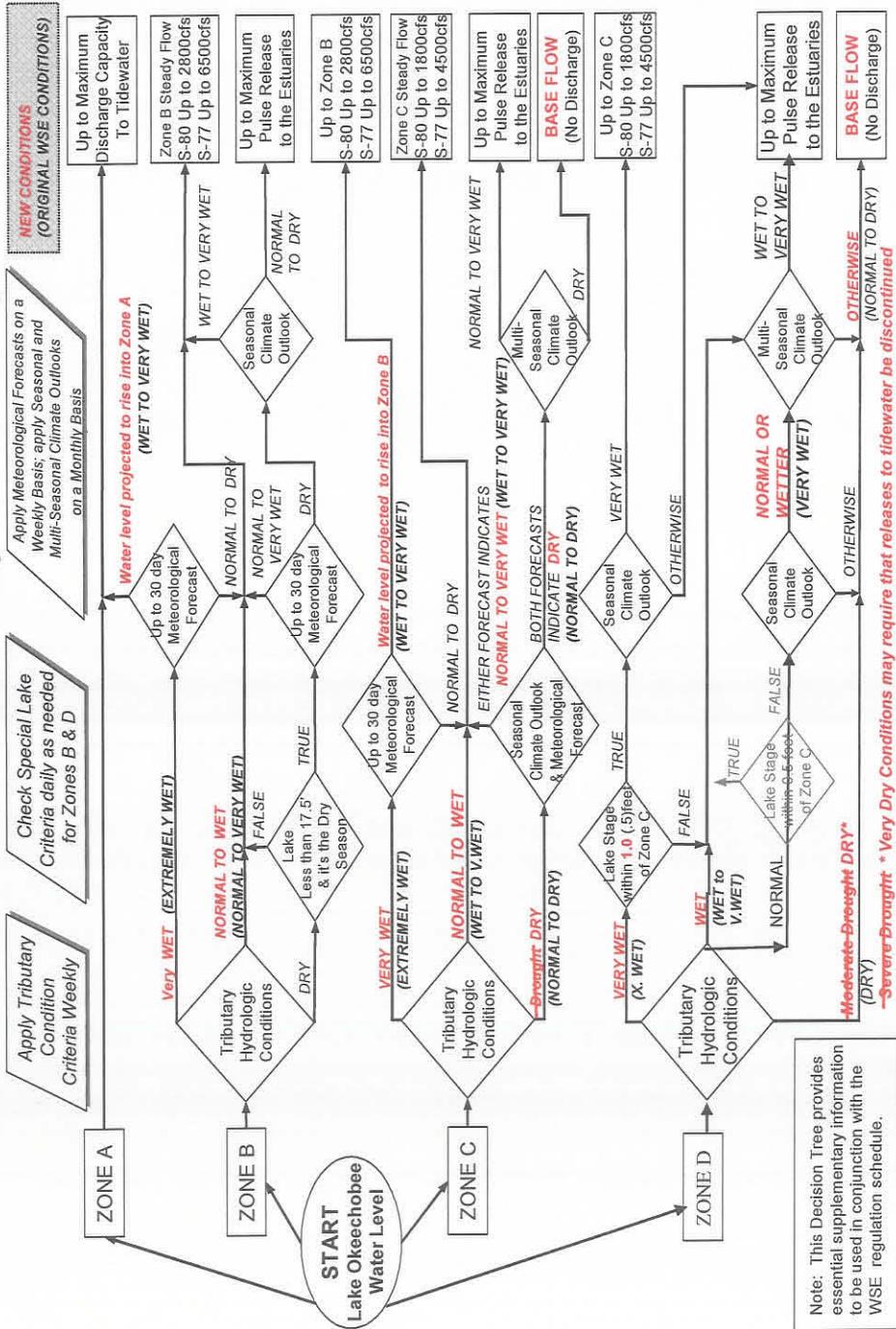


FIGURE A-4: DECISION TREE, PART 2 FOR ALTERNATIVE 1BS2-A17.25, ALTERNATIVE 1BS2-M, AND ALTERNATIVE 4-A17.25

/OKEECHOBEE/ZONE A/ELEV-REG/01JAN1960/R-DECADE/ALT1BS2-M/

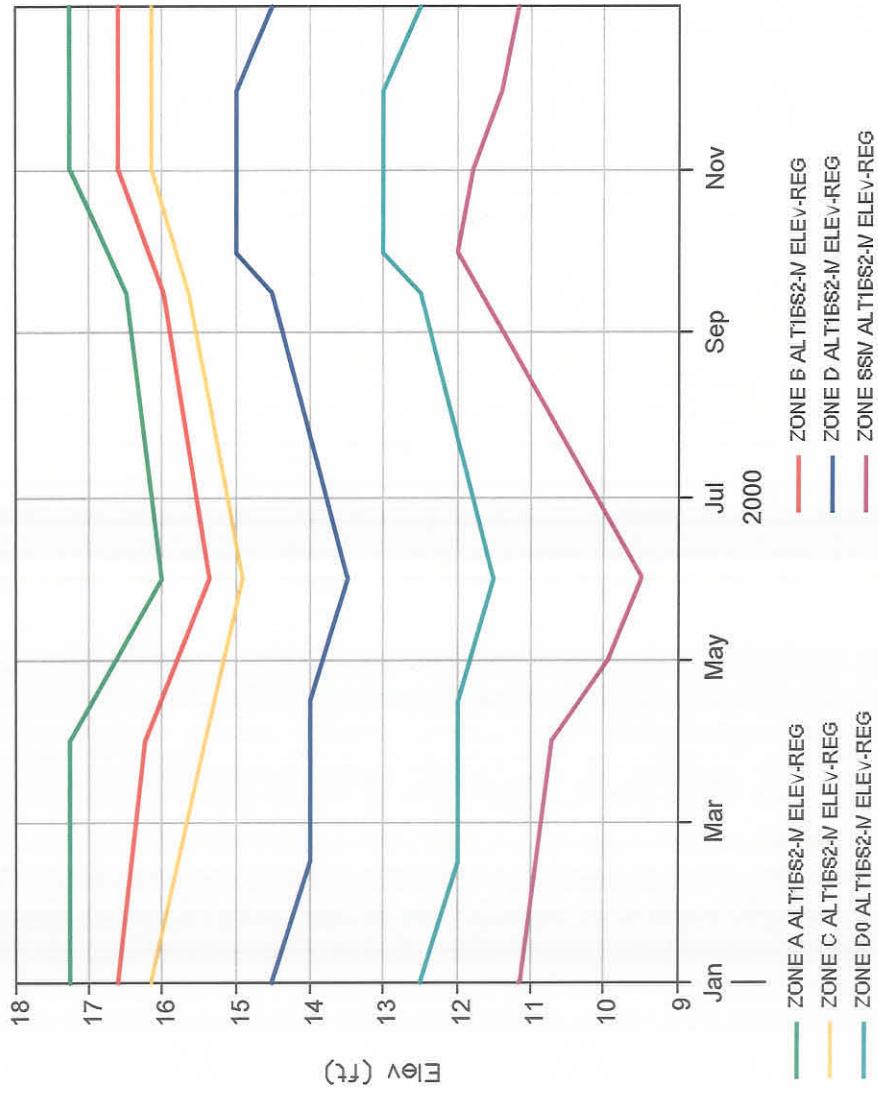


FIGURE A-5: REGULATION SCHEDULE FOR ALTERNATIVE 1BS2-M (2006 SEIS)

/OKEECHOEE/BLACK/ELEV-REG/01JAN1960/IR-DECADE/ALT2A-A17.25/

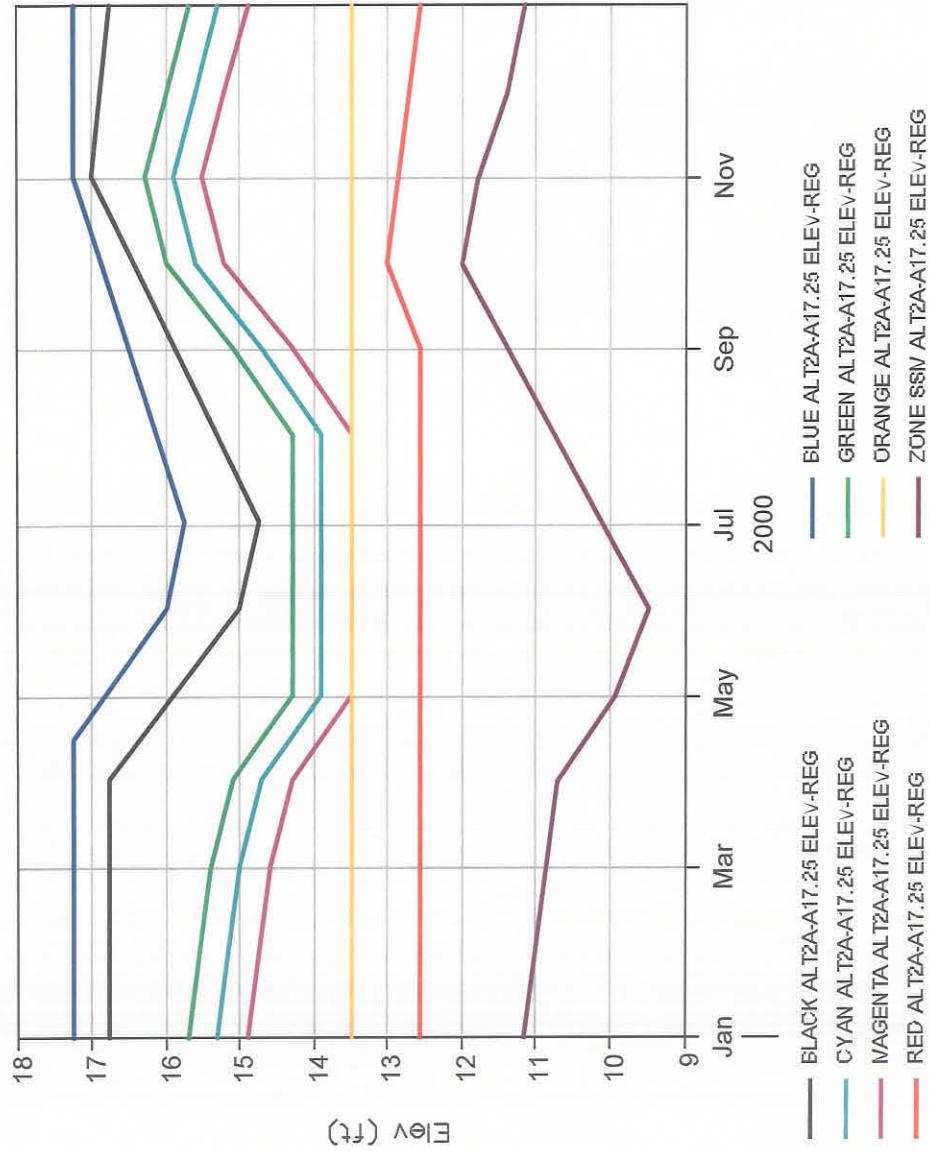


FIGURE A-6: REGULATION SCHEDULE FOR ALTERNATIVE 2A-A17.25

LORSS Operational Guidelines Decision Tree

Part 1: Define Lake Okeechobee Discharges to the Water Conservation Areas

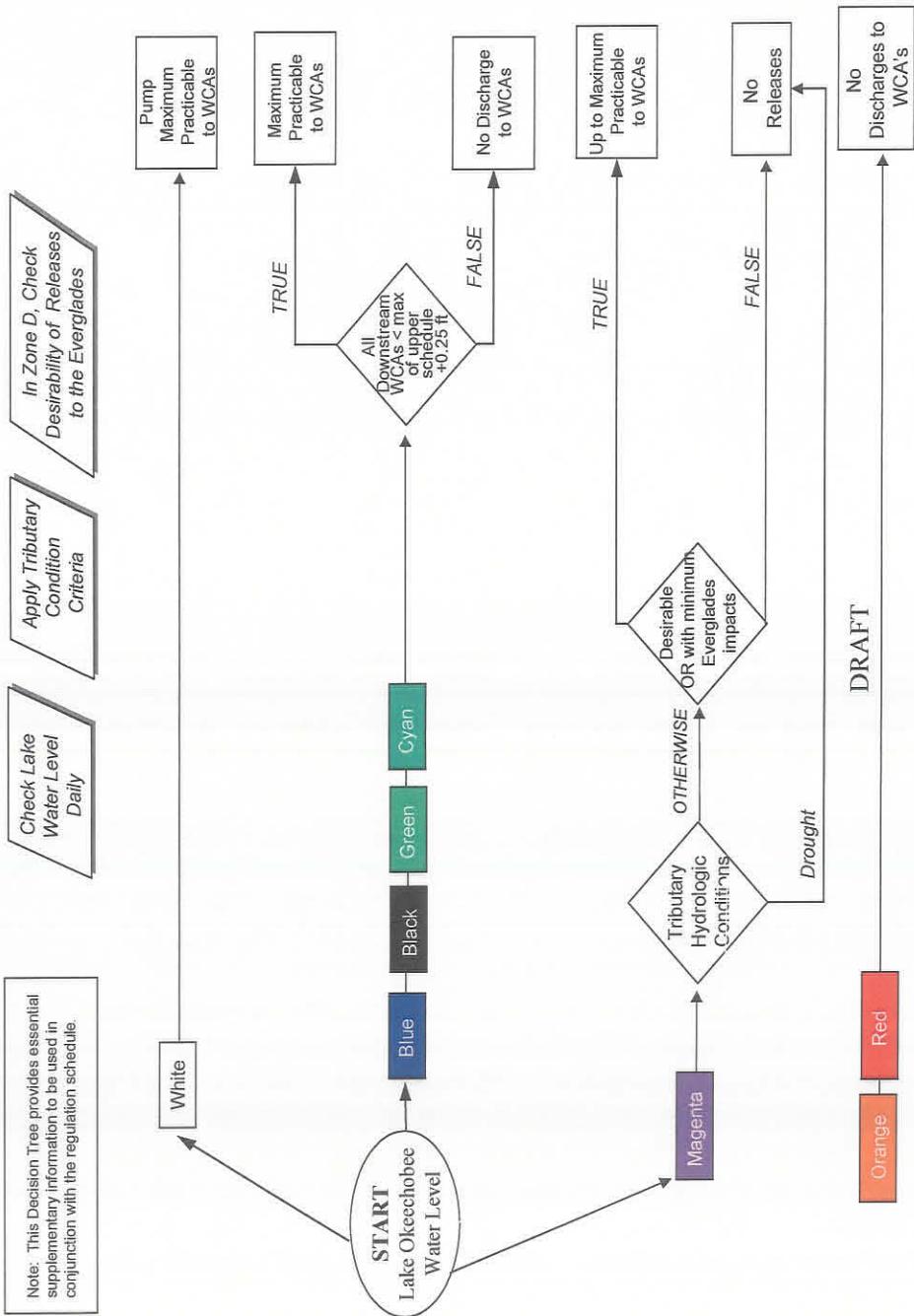
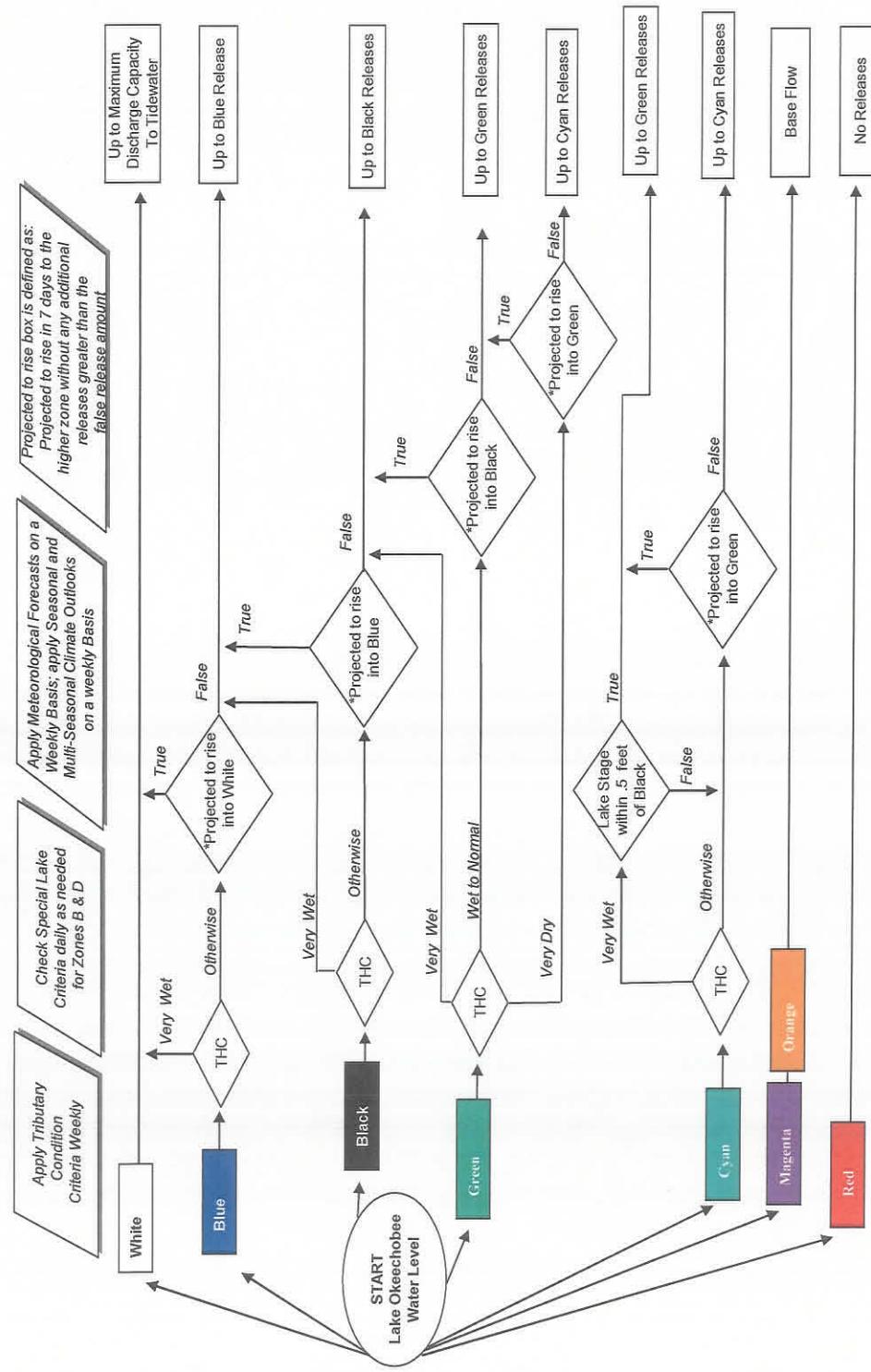


FIGURE A-7: DECISION TREE, PART 1 FOR ALTERNATIVE 2A-B AND ALTERNATIVE 2A-M

LORS Operational Guidance
Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)



Very dry conditions may require that releases to tidewater be discontinued

FIGURE A-8: DECISION TREE, PART 2 FOR ALTERNATIVE 2A-B AND ALTERNATIVE 2A-M

/OKEECHOBEE/BLACK/ELEV-REG/01JAN1960/IR-DECADE/ALT2A-M/

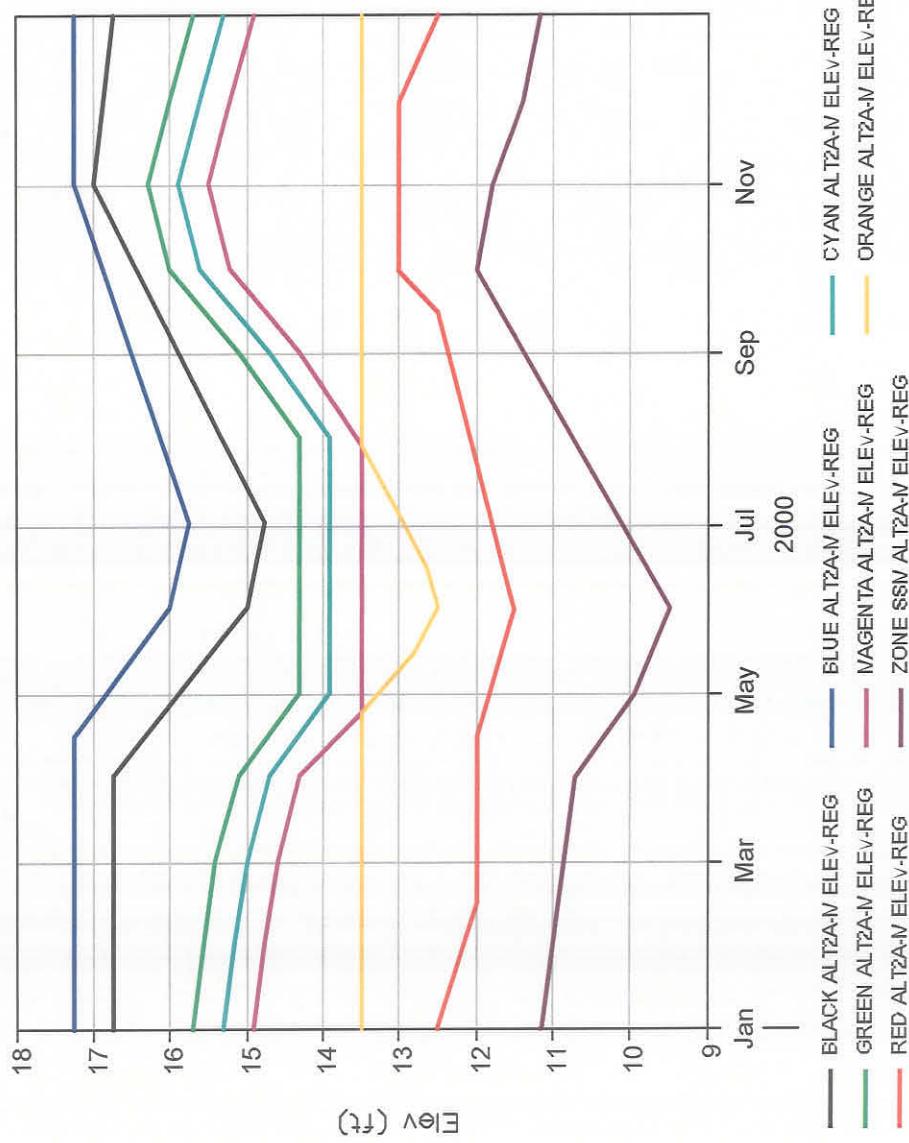


FIGURE A-9: REGULATION SCHEDULE FOR ALTERNATIVE 2A-M

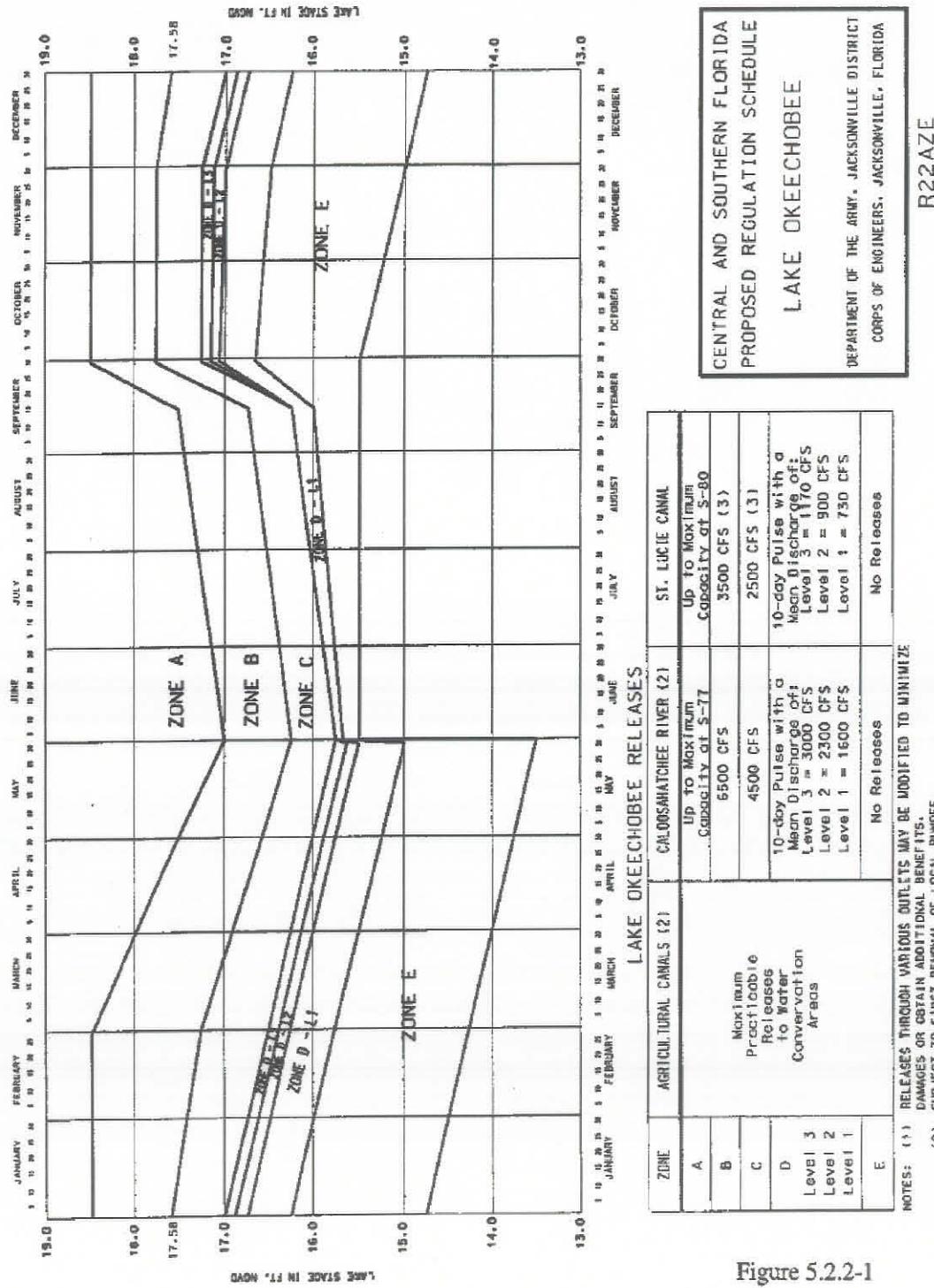


Figure 5.2.2-1

/OKEECHOBEE/BASE FLOW ZONE/ELEV-REG/01JAN1960/IR-DECADE/ALT3-B/

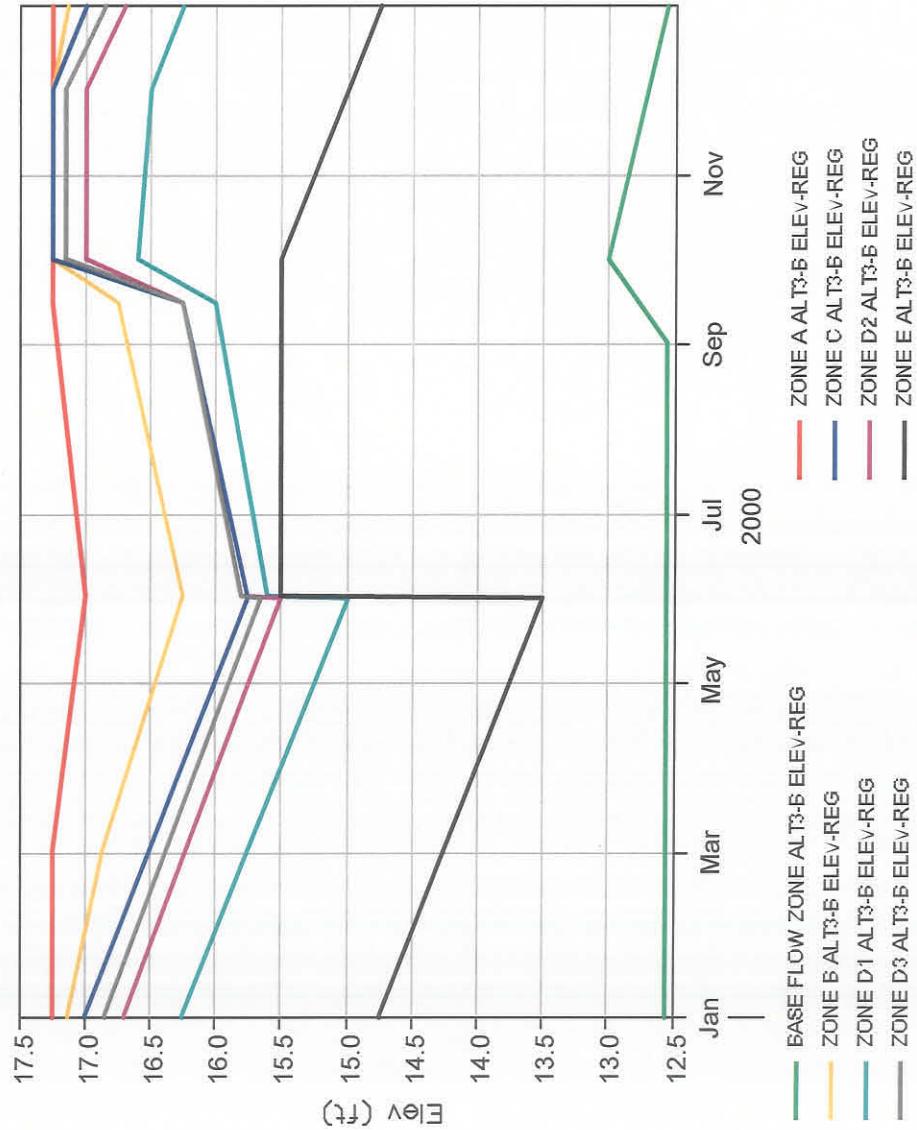


FIGURE A-11: REGULATION SCHEDULE FOR ALTERNATIVE 3-B

Lake Okeechobee

A review of the simulation output for Lake Okeechobee requires consideration of a wide range of performance metrics including flood protection, lake ecology, and navigation. Figures C-1 through C-10 are examples of the modeling results as related to the following discussion points for Lake Okeechobee performance. All of the figures can be reviewed at:

<http://hpm.saj.usace.army.mil/loweb/sfwmm>.

A. Regulatory Releases

An overview of the trends of alternative performance is captured from a review of the performance measure showing average annual flood control releases from Lake Okeechobee and the associated distribution to tidewater through the L-8 canal, the SLE through S-308, the Caloosahatchee Estuary through S-77, and south to the WCAs through S-351 (to the Hillsborough and North New River Canals) and S-354 (to the Miami River Canal), which are shown in Figures C-1 and C-2. The numbers shown in the average annual flood control graphic do not include low-level regulatory base flow releases to the estuaries when the base flow release is simulated as estuarine demand in the SFWMM, an option used for several alternatives. Average annual base flow releases from Lake Okeechobee to the SLE are summarized: 0.0 thousand acre-feet (kAF) for Alternative T1 (base flow simulated as regulatory release measured at S-80, not below S-80 at the estuary); 19 kAF for Alternative T2; and 19 kAF for Alternative T3. Average annual base flow releases from Lake Okeechobee to the Caloosahatchee Estuary are summarized: 60 kAF for Alternative 1bS2-A17.25; 59 kAF for Alternative 1bS2-m; 44 kAF for Alternative T1; 41 kAF for Alternative T2; and 40 kAF for Alternative T3. Ranking the alternatives with respect to average annual flood control (regulatory) discharge to the STE (including base flow), the following trend is observed (highest to lowest): Alternative T2 (167 kAF); Alternative T3 (164 kAF); Alternative T1 (145 kAF); No Action Alternative (142 kAF); Alternative 1bS2-m (135 kAF); and lastly, Alternative 1bS2-A17.25 (130 kAF). Ranking the alternatives with respect to average annual flood control discharge to the Caloosahatchee Estuary (including base flow), the following trend is observed (highest to lowest): Alternatives 1bS2-m and T1 (464 kAF); Alternative 1bS2-A17.25 (460 kAF); Alternative T3 (415 kAF); Alternative T2 (410 kAF); and lastly, No Action Alternative (labeled as 07LORS in all performance measure graphics, 379 kAF). Ranking the alternatives with respect to average annual flood control releases to the L-8 canal to be routed to Lake Worth Lagoon, the following trend is observed (highest to lowest): Alternative 1bS2-m and Alternative 1bS2-A17.25 (114-115 kAF); Alternative T1 (107 kAF); Alternative T2 (102 kAF); Alternative T3 (100 kAF); and No Action Alternative (77 kAF). Generally, the alternatives that most significantly lower the lake stages result in the most significant increase in discharge volume to the estuaries, including the Callosahatchee, St. Lucie, and Lake Worth Lagoon. This point is emphasized by the assumption of the treatment capacity constraint for STA-3/4, which is utilized to limit the average annual volume of lake regulatory releases passed south to STA-3/4 from S-351 and S-354 to a comparable volume for the No Action Alternative condition and all evaluated LORSS Alternatives. Potential changes in flows to the estuaries will be later discussed in this section.

Water supply backpumping to Lake Okeechobee is not included in the SFWMM modeling of the LORSS alternatives or No Action alternative; there is no increase in water supply backpumping

/OKEECHOBEE/BASE FLOW ZONE/ELEV-REG/01JAN1960/IR-DECADE/ALT4-A17.25/

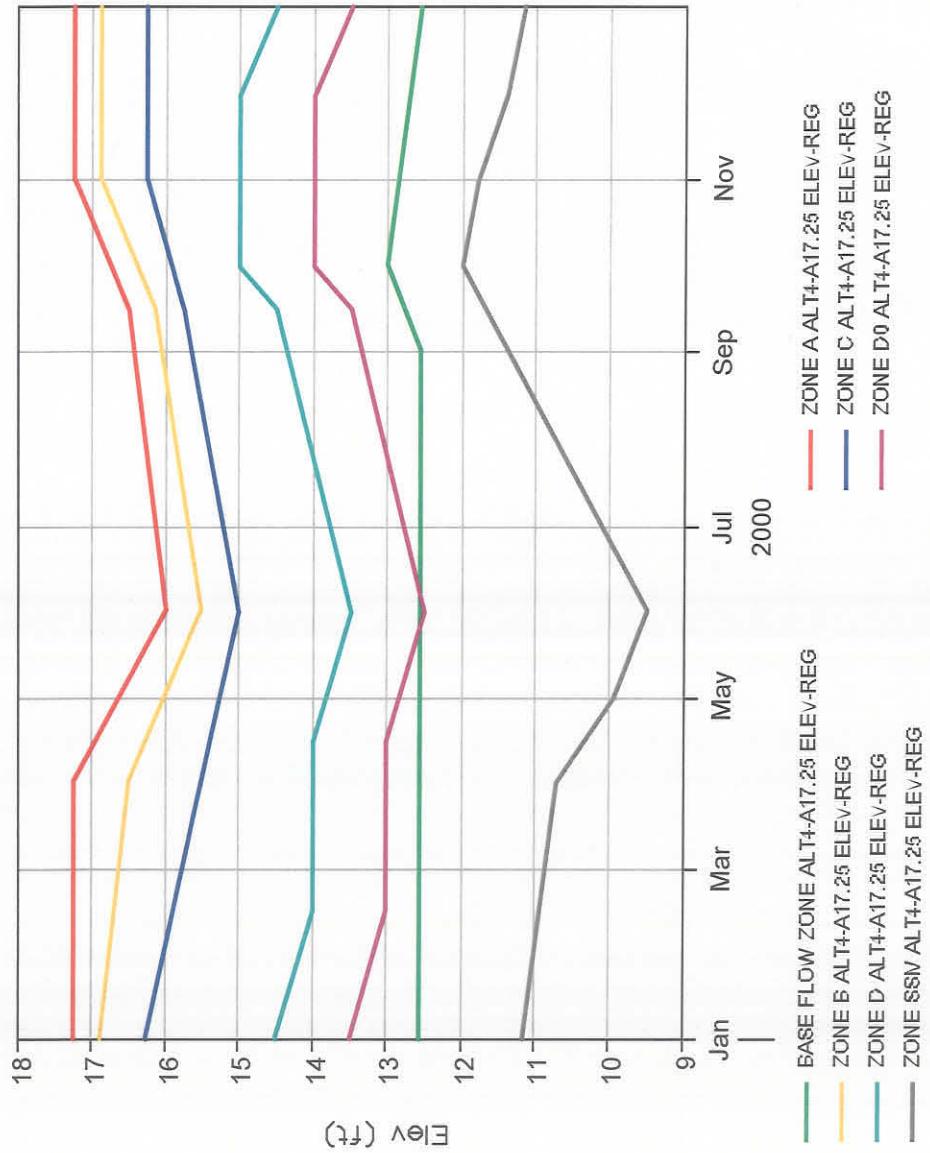


FIGURE A-12: REGULATION SCHEDULE FOR ALTERNATIVE 4-A17.25

Lake Okeechobee Operational Guidance

Part D: Establish Allowable Lake Okeechobee Releases to the Water Conservation Areas

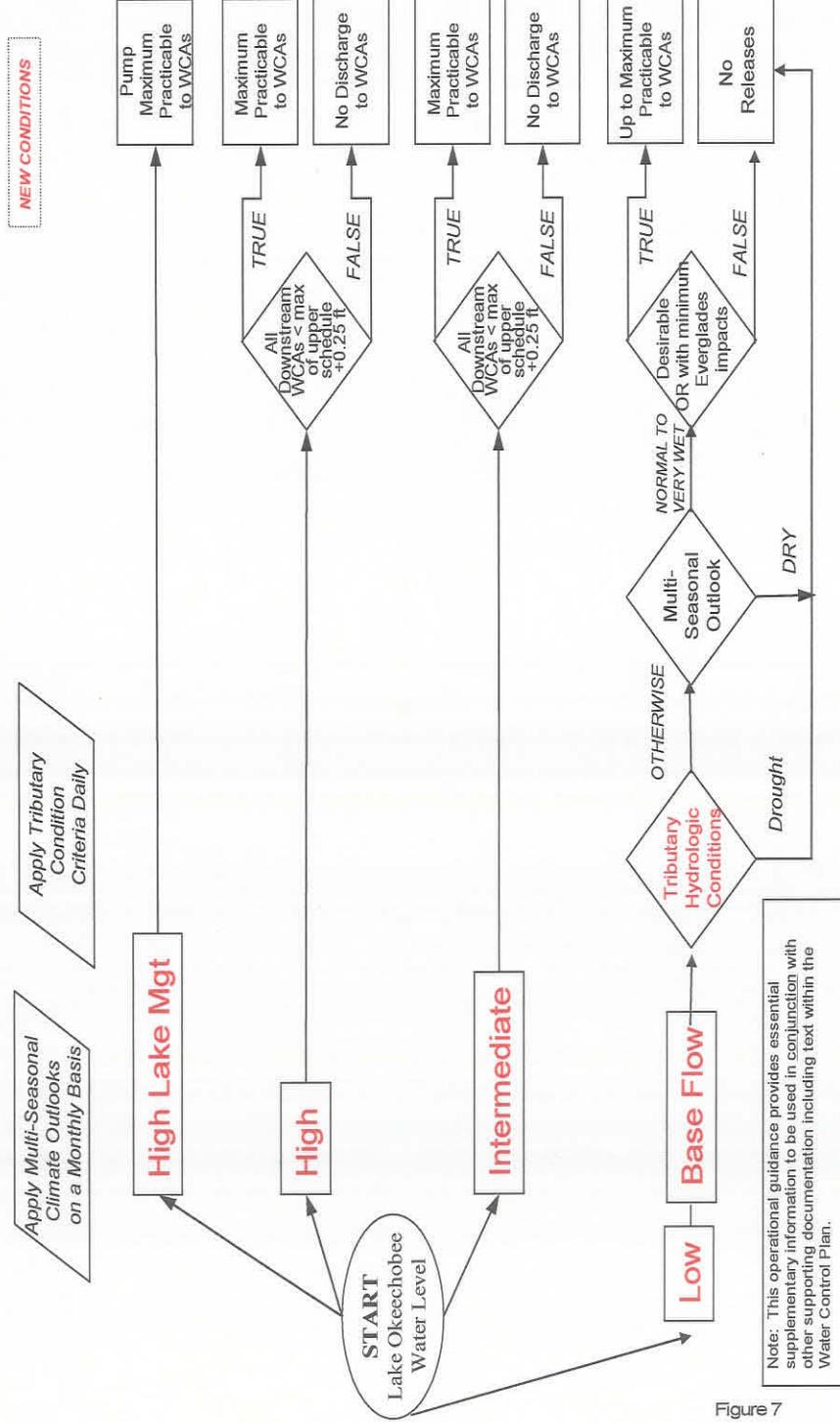


Figure 7

**FIGURE A-13: DECISION TREE, PART 1 FOR ALTERNATIVE 1BS2-A17.25, ALTERNATIVE 1BS2-M,
ALTERNATIVE T1, ALTERNATIVE T2, AND ALTERNATIVE T3**

/OKEECHOEE/ZONE A/ELEV-REG/01JAN1960/IR-DECADE/ALTIBS2-A17.25/

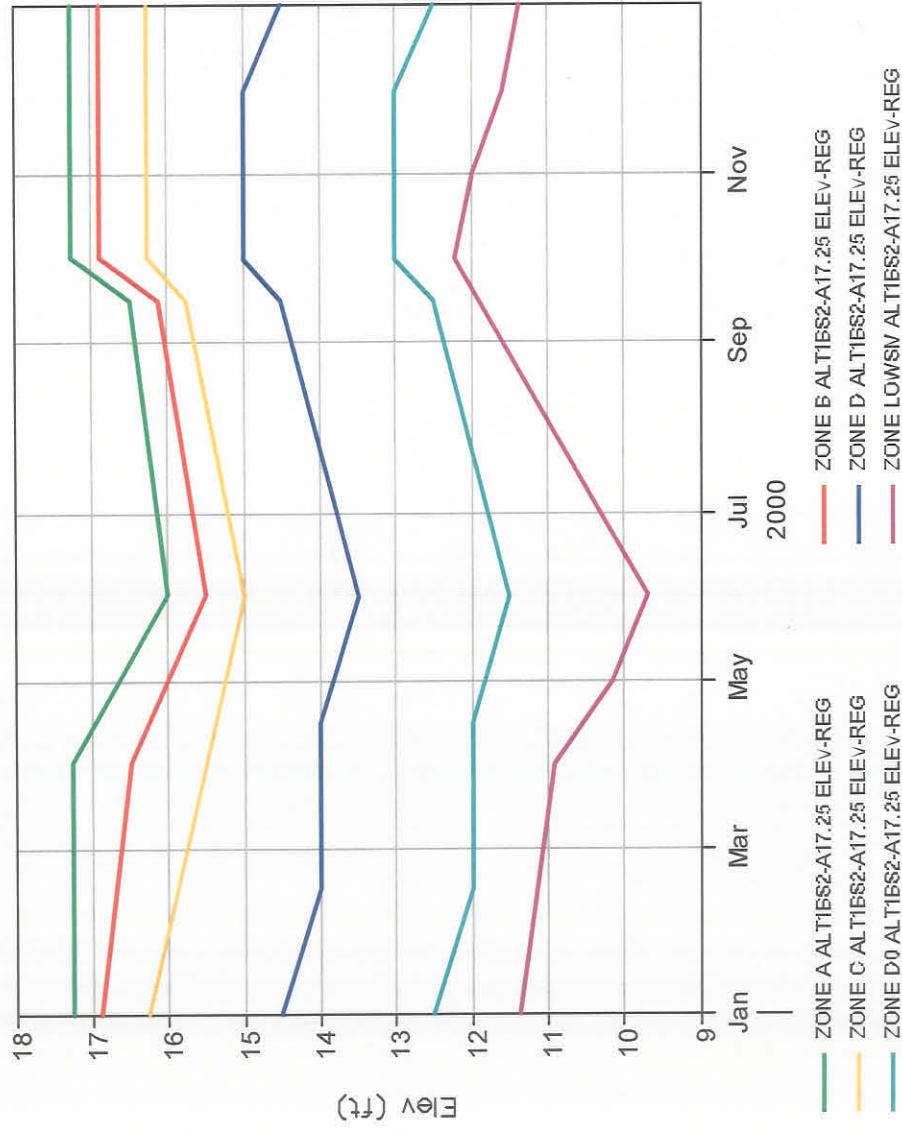


FIGURE A-14: REGULATION SCHEDULE FOR ALTERNATIVE 1BS2-A17.25 (2007 SEIS)

/OKEECHOEE/ZONE A/ELEV-REG/01JAN1960/R-DECade/ALT1BS2-M/

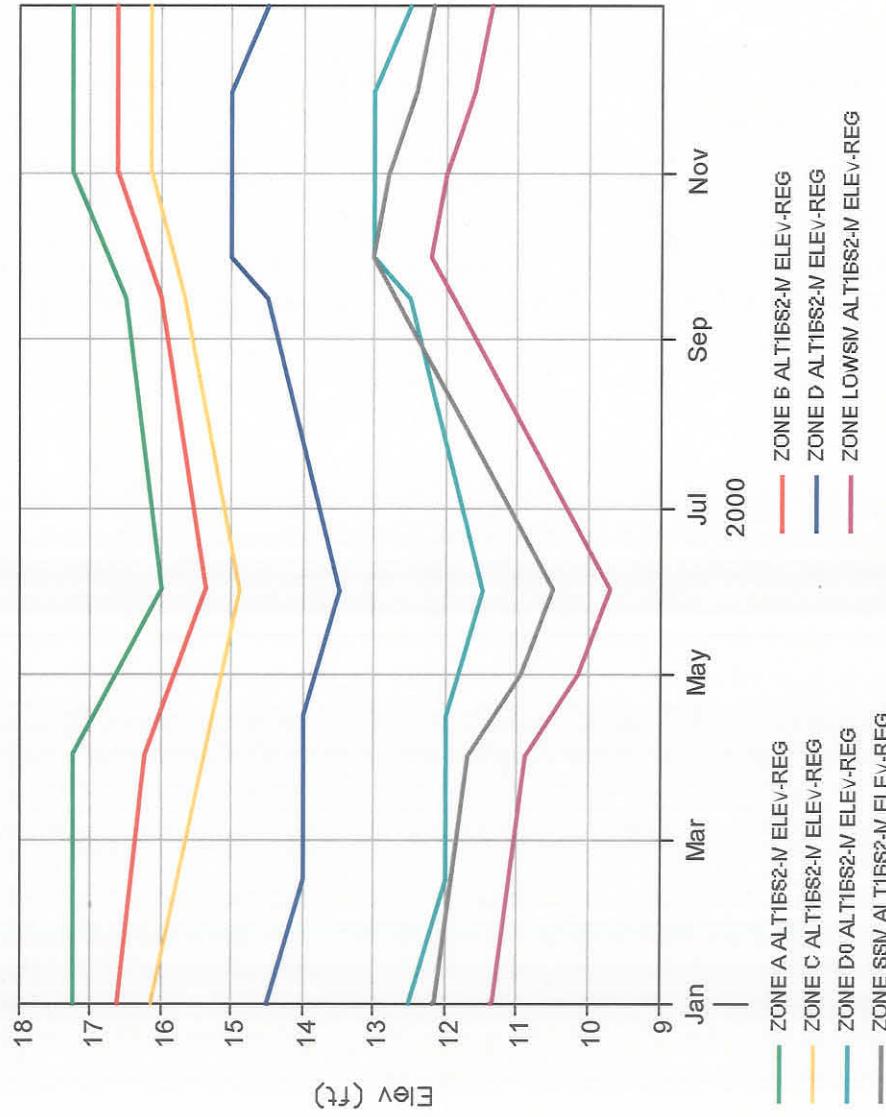


FIGURE A-15: REGULATION SCHEDULE FOR ALTERNATIVE 1BS2-A17.25 (2007 SEIS)

Lake Okeechobee Operational Guidance (1B-T1)

Part 2: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)

Note: This operational guidance provides essential supplementary information to be used in conjunction with other supporting documentation including text within the Water Control Plan.

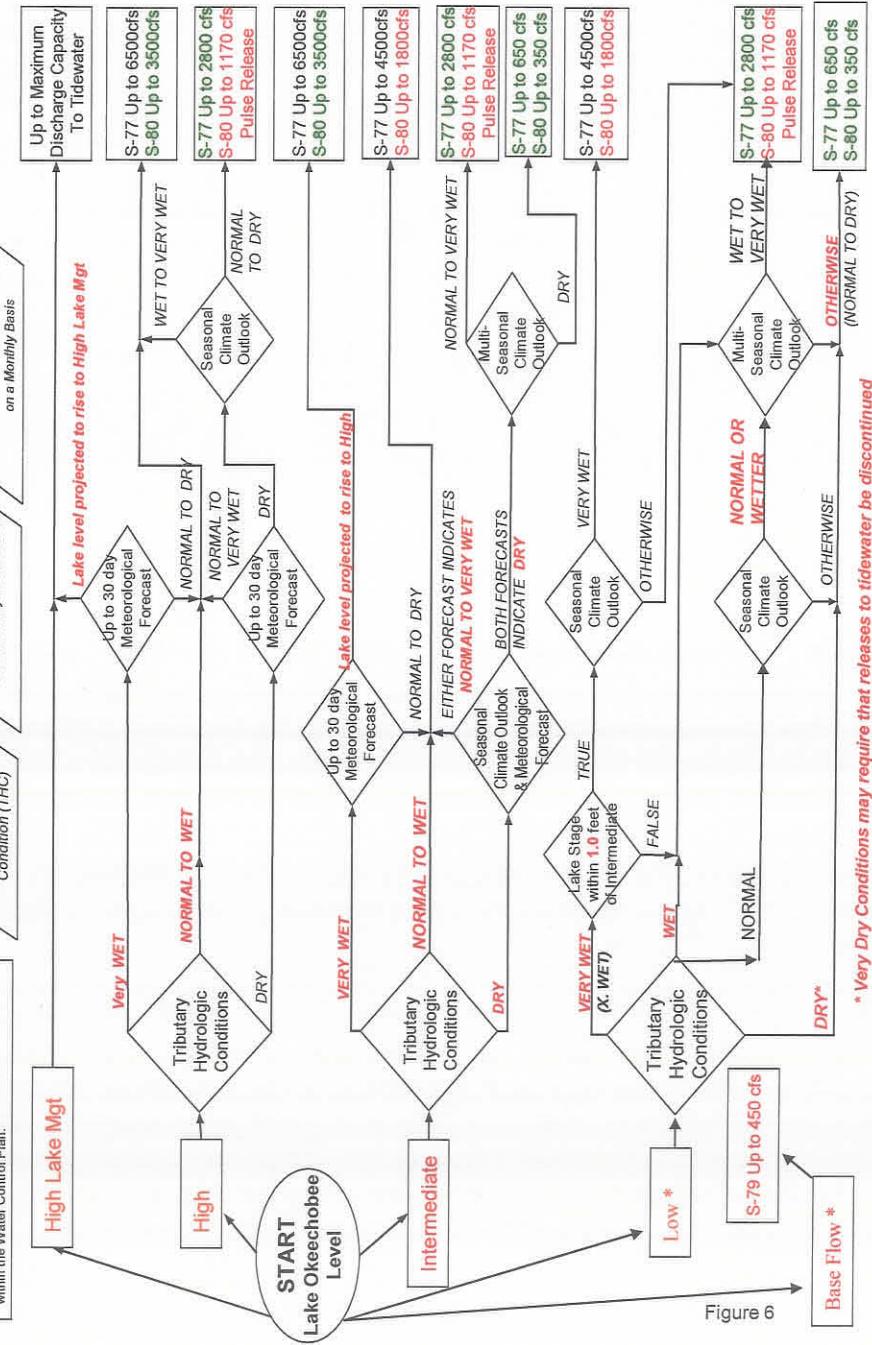


Figure 6

FIGURE A-16: DECISION TREE, PART 2 FOR ALTERNATIVE T1

Lake Okeechobee Management Bands (1B-T1)
*(To include water supply demand releases)

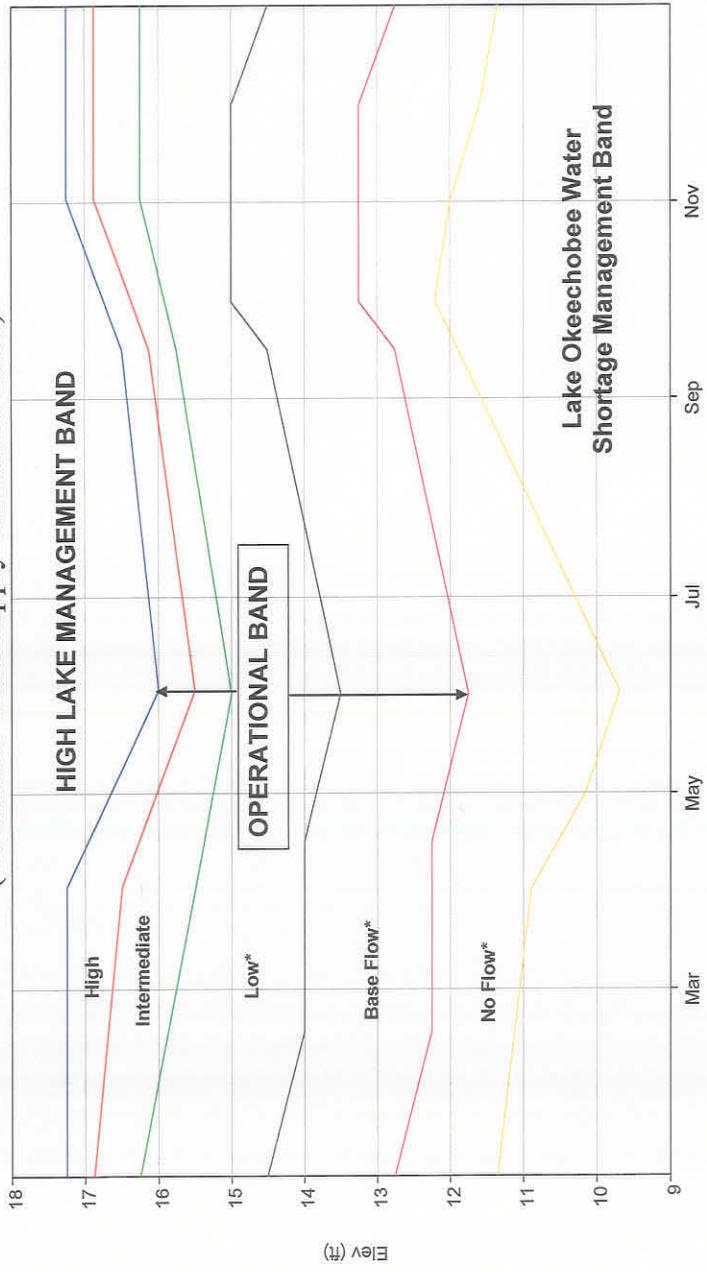


FIGURE A-17: REGULATION SCHEDULE FOR ALTERNATIVE T1

Lake Okeechobee Operational Guidance (1B-T2)

Part 2: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)

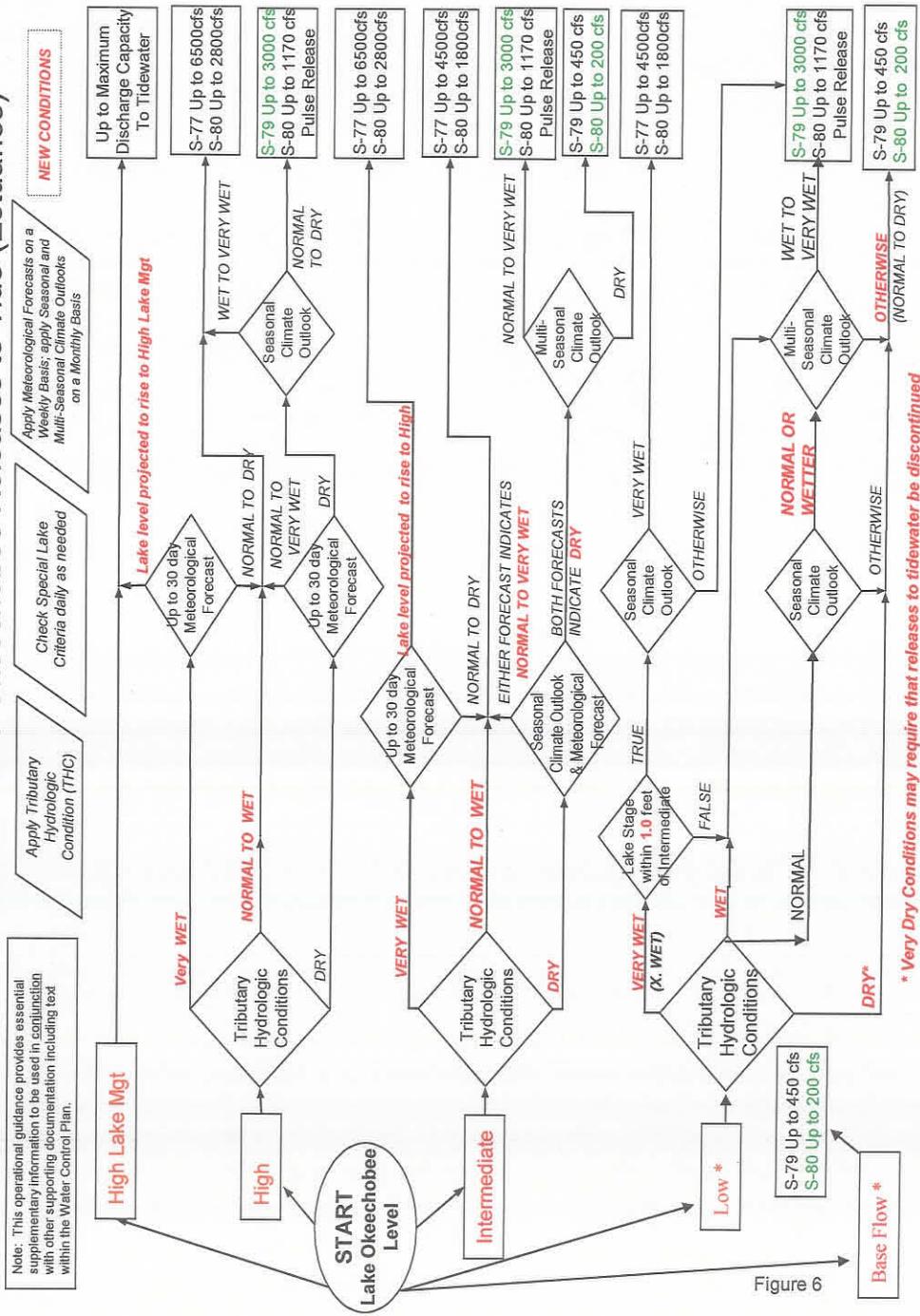


FIGURE A-18: DECISION TREE, PART 2 FOR ALTERNATIVE T2

Lake Okeechobee Management Bands (1B-T2)
*(To include water supply demand releases)

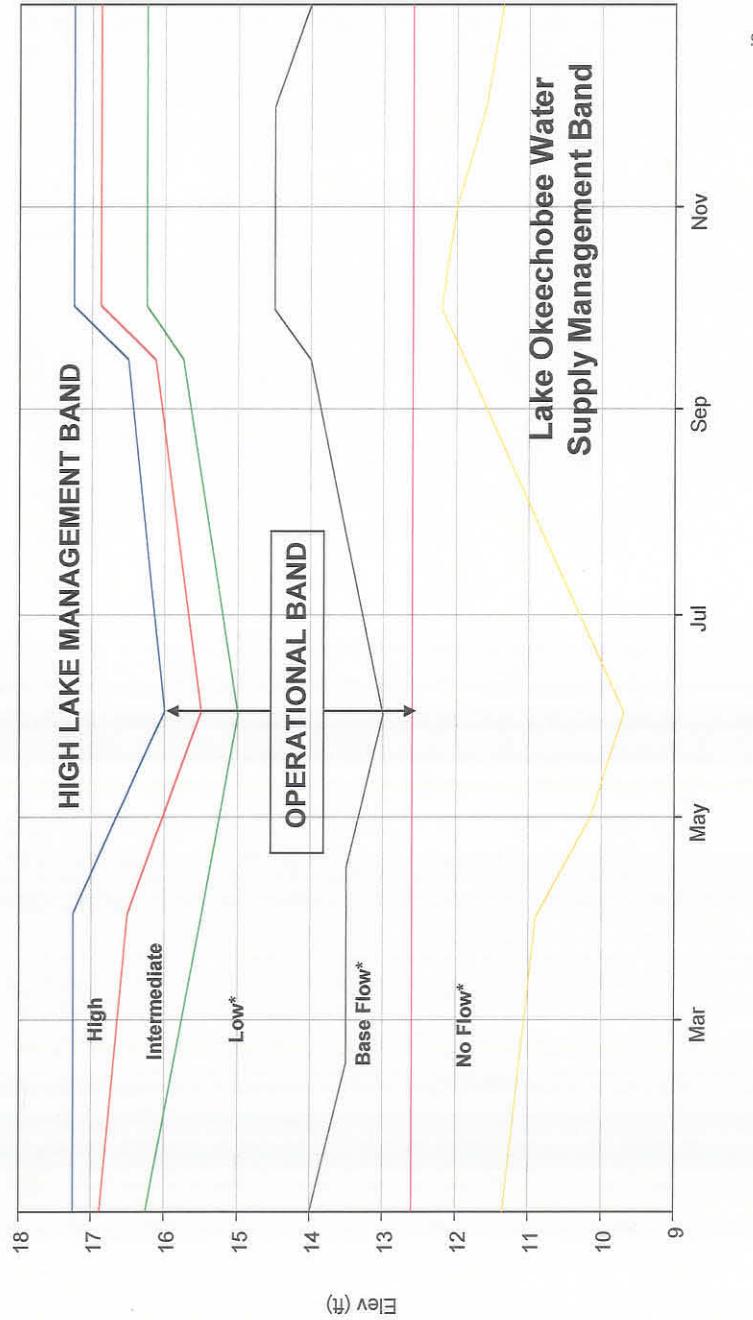
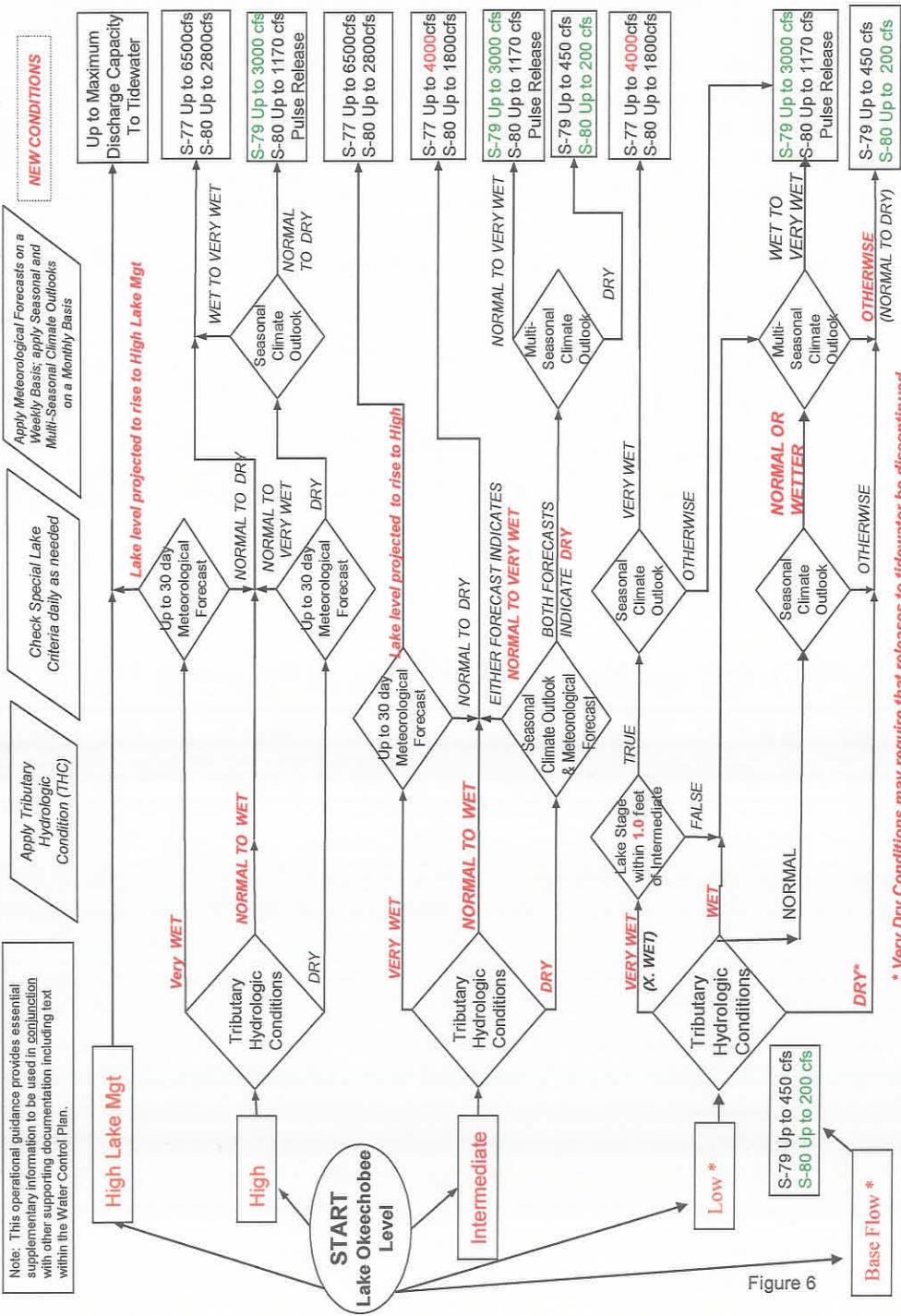


FIGURE A-19: REGULATION SCHEDULE FOR ALTERNATIVE T2

Lake Okeechobee Operational Guidance (1B-T3)

Part 2: Establish Allowable Lake Okeechobee Releases to Tide (Estuaries)

Note: This operational guidance provides essential supplementary information to be used in conjunction with other supporting documentation including text within the Water Control Plan.



BAUDIMILOVÉSÍN A LAUREMAGN OI SASBATA / VÍVÍ A MÍHÁ / SEMMISZOMORÍTÓ ÉRÉM

FIGURE A-20: DECISION TREE, PART 2 FOR ALTERNATIVE T3

Lake Okeechobee Management Bands (1B-T3)

*(To include water supply demand releases)

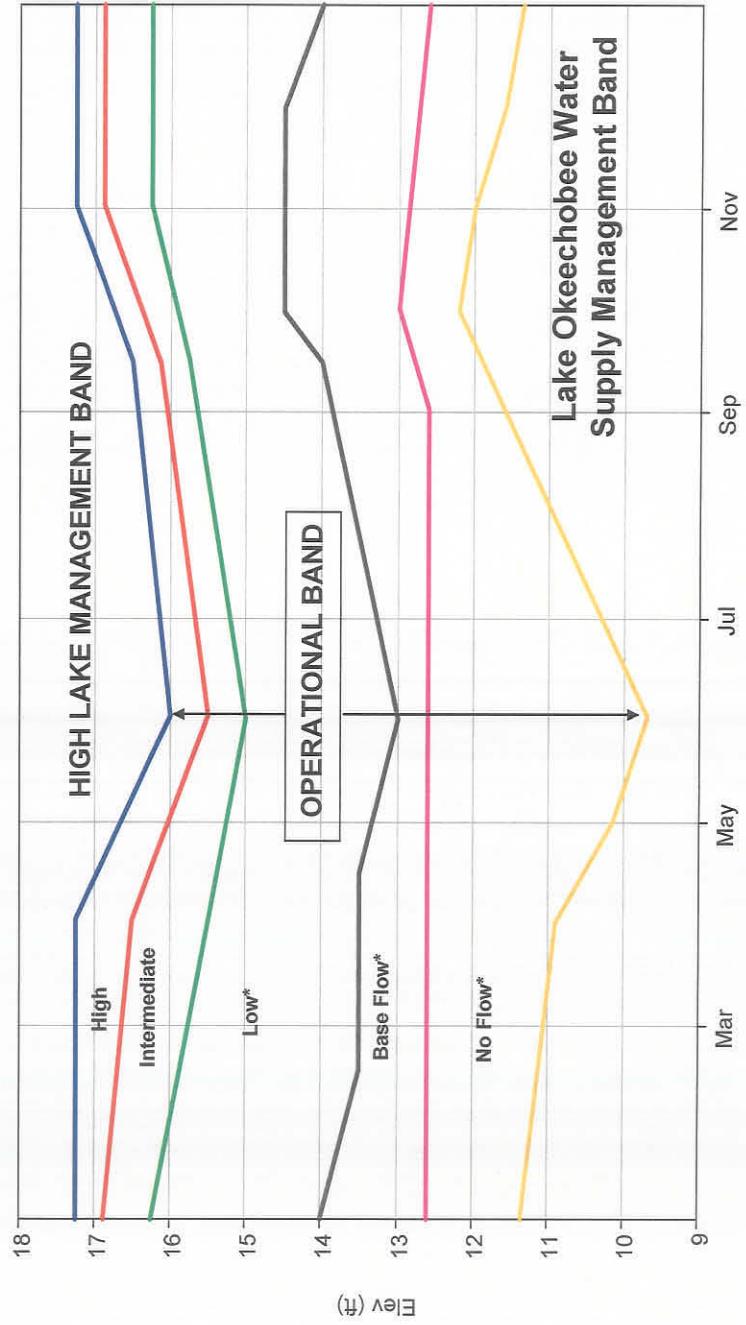


FIGURE A-21: REGULATION SCHEDULE FOR ALTERNATIVE T3

ATTACHMENT B
SFWMM Background Figures

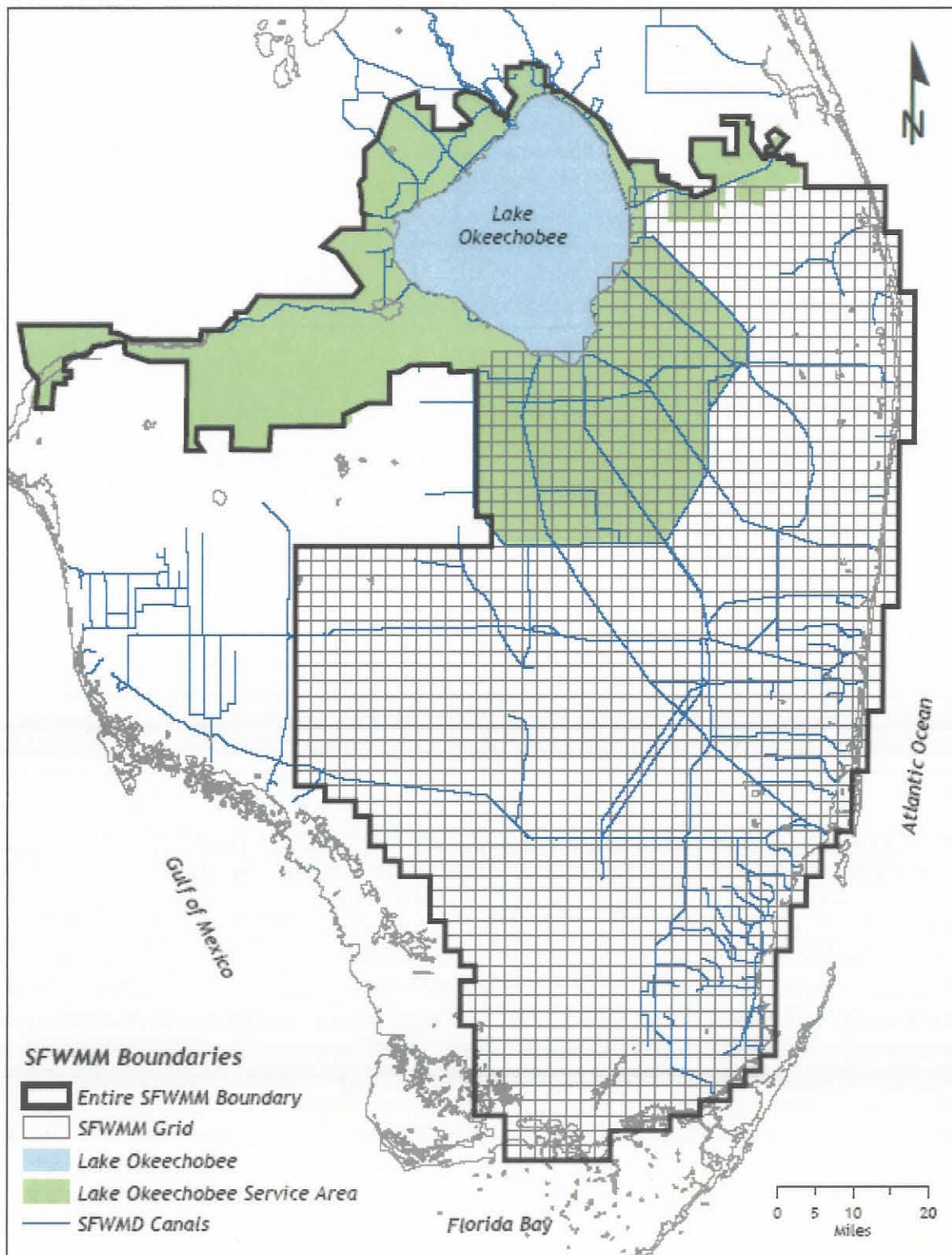


FIGURE B-1: SOUTH FLORIDA WATER MANAGEMENT MODEL BOUNDARIES

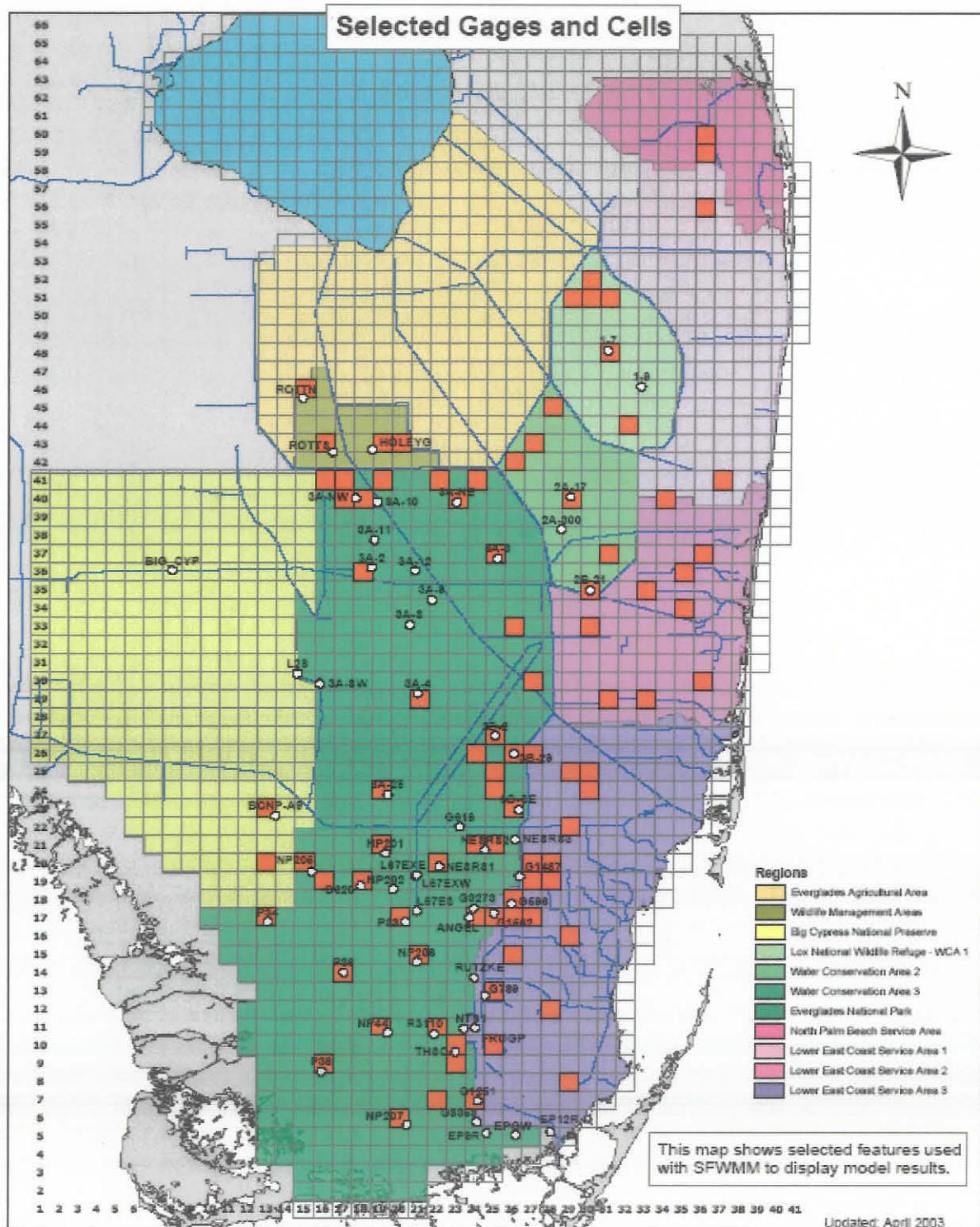


FIGURE B-2: GAGE AND MONITORING POINT LOCATIONS REPORTED BY THE SFWMM

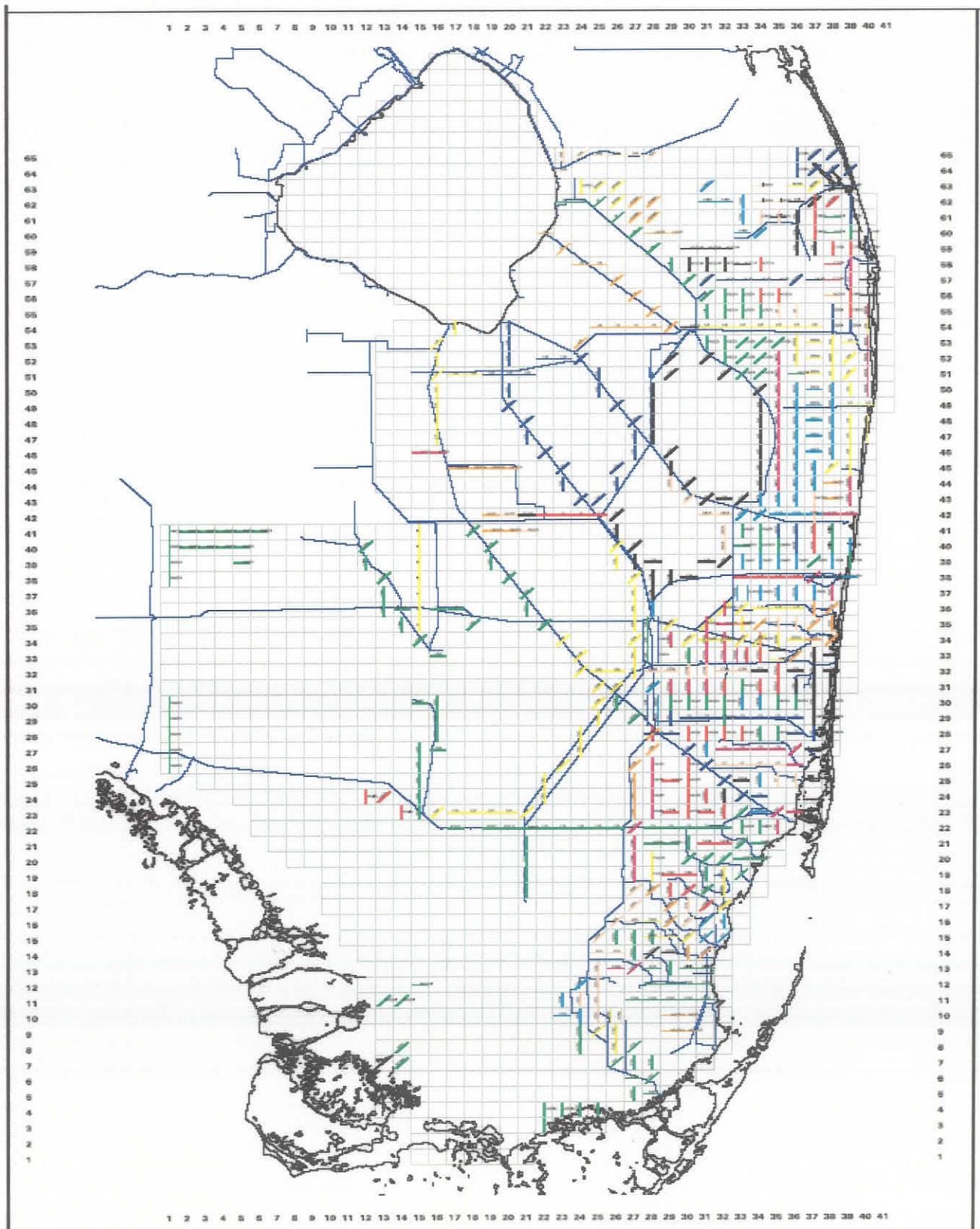


FIGURE B-3: SFWMM CANAL NETWORK (VERSION 5.0)

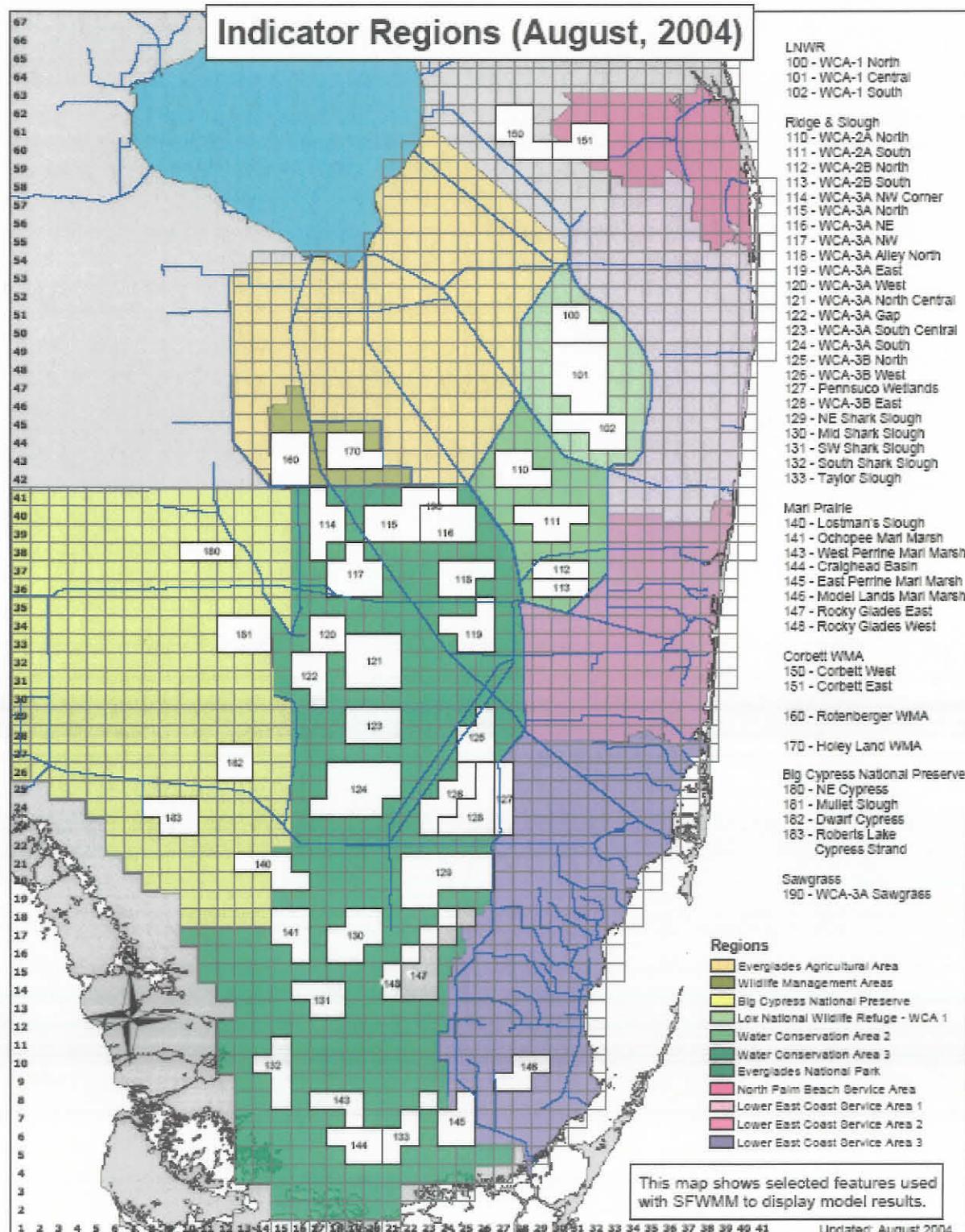


FIGURE B-4: SFWMM INDICATOR REGIONS (VERSION 5.0)

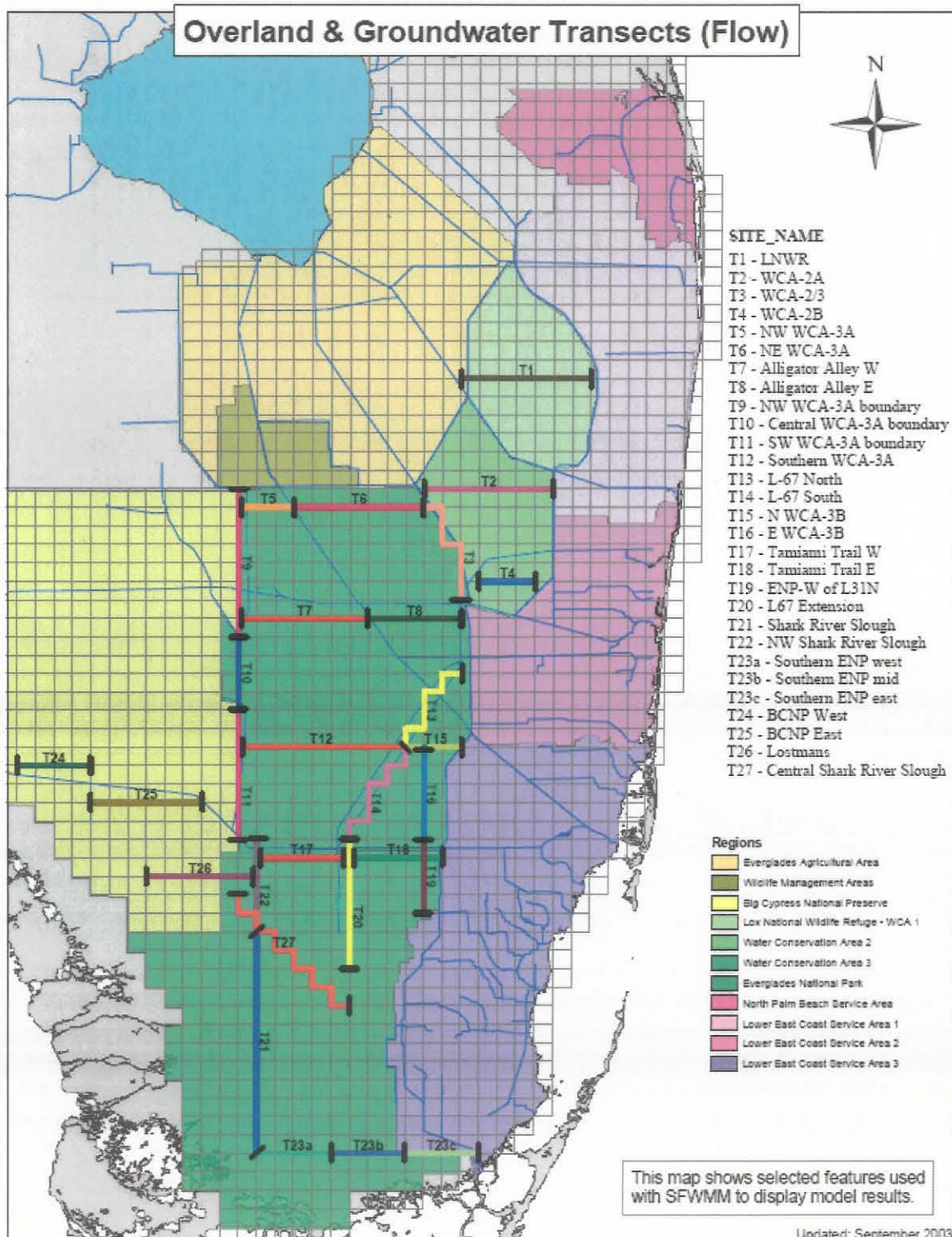


FIGURE B-5: SFWMM OVERLAND FLOW TRANSECTS

ATTACHMENT C

Selected Performance Measures and Indicators: 2007 LORSS SEIS (TSP Refinements)

Mean Annual Flood Control Releases from Lake Okeechobee for the 36 yr (1965 – 2000) Simulation

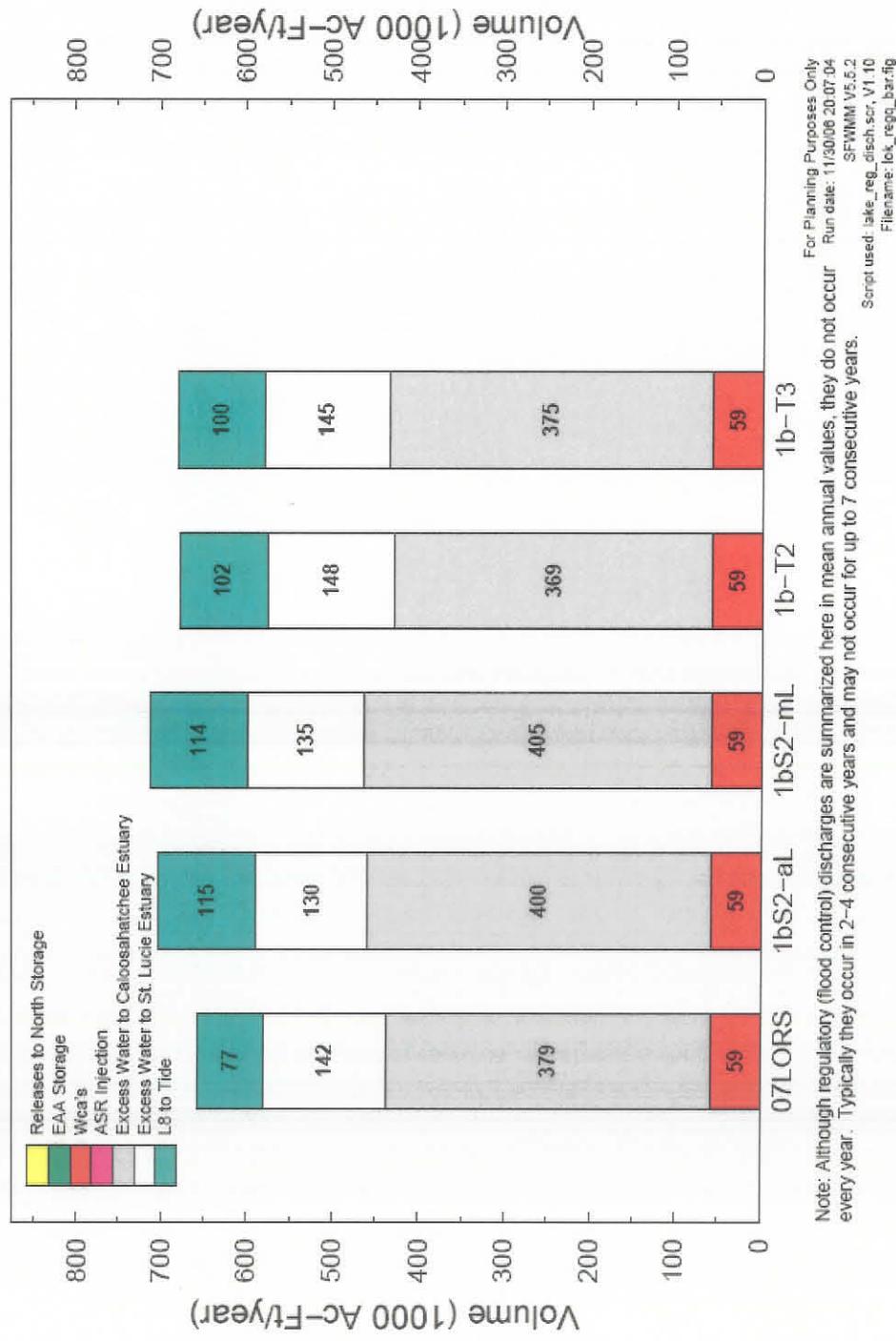


FIGURE C-1: MEAN ANNUAL FLOOD CONTROL RELEASES FROM LAKE OKEECHOBEE (1)

Mean Annual Flood Control Releases from Lake Okeechobee for the 36 yr (1965 – 2000) Simulation

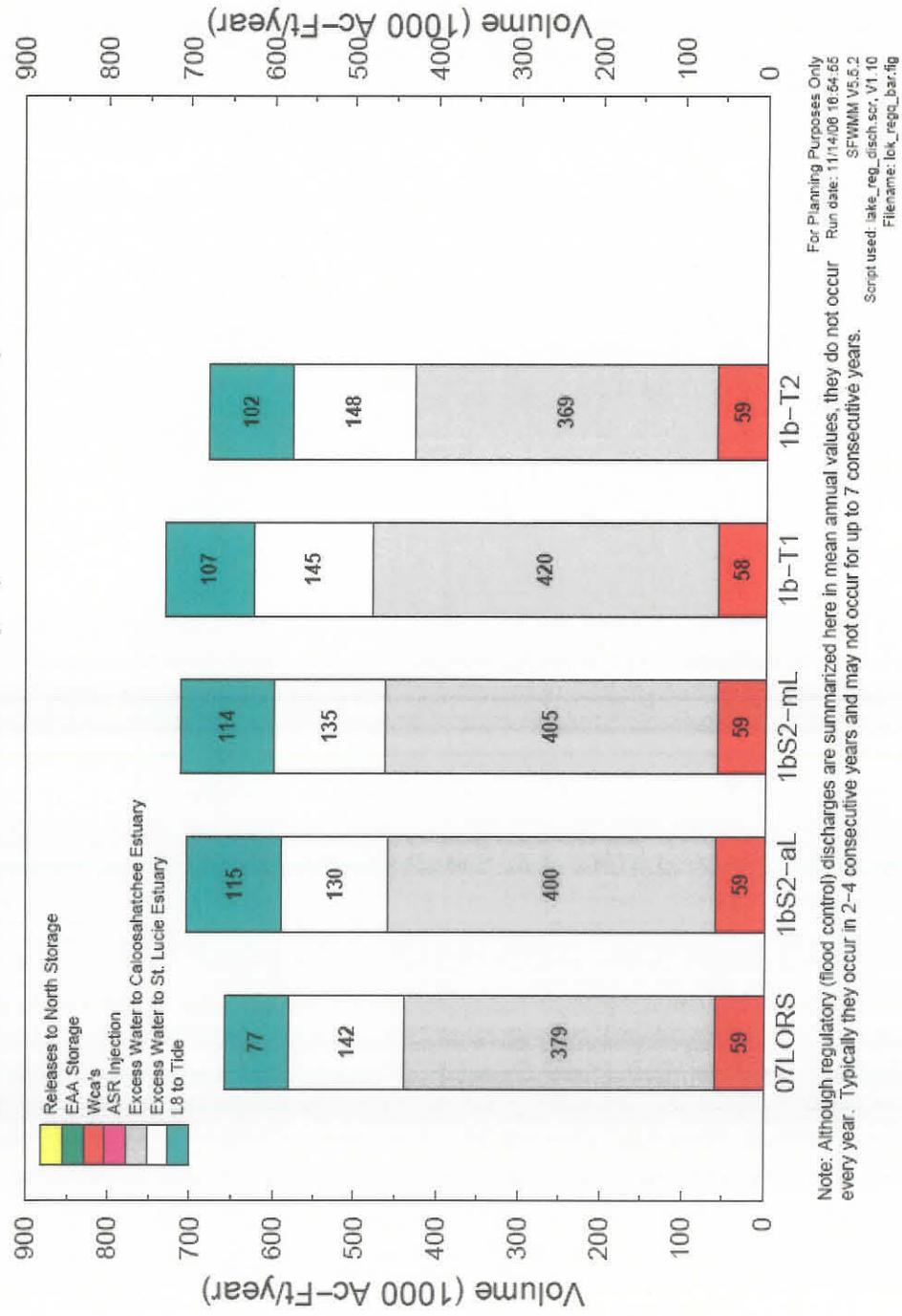


FIGURE C-2: MEAN ANNUAL FLOOD CONTROL RELEASES FROM LAKE OKEECHOBEE (2)

Stage Duration Curves for Lake Okeechobee

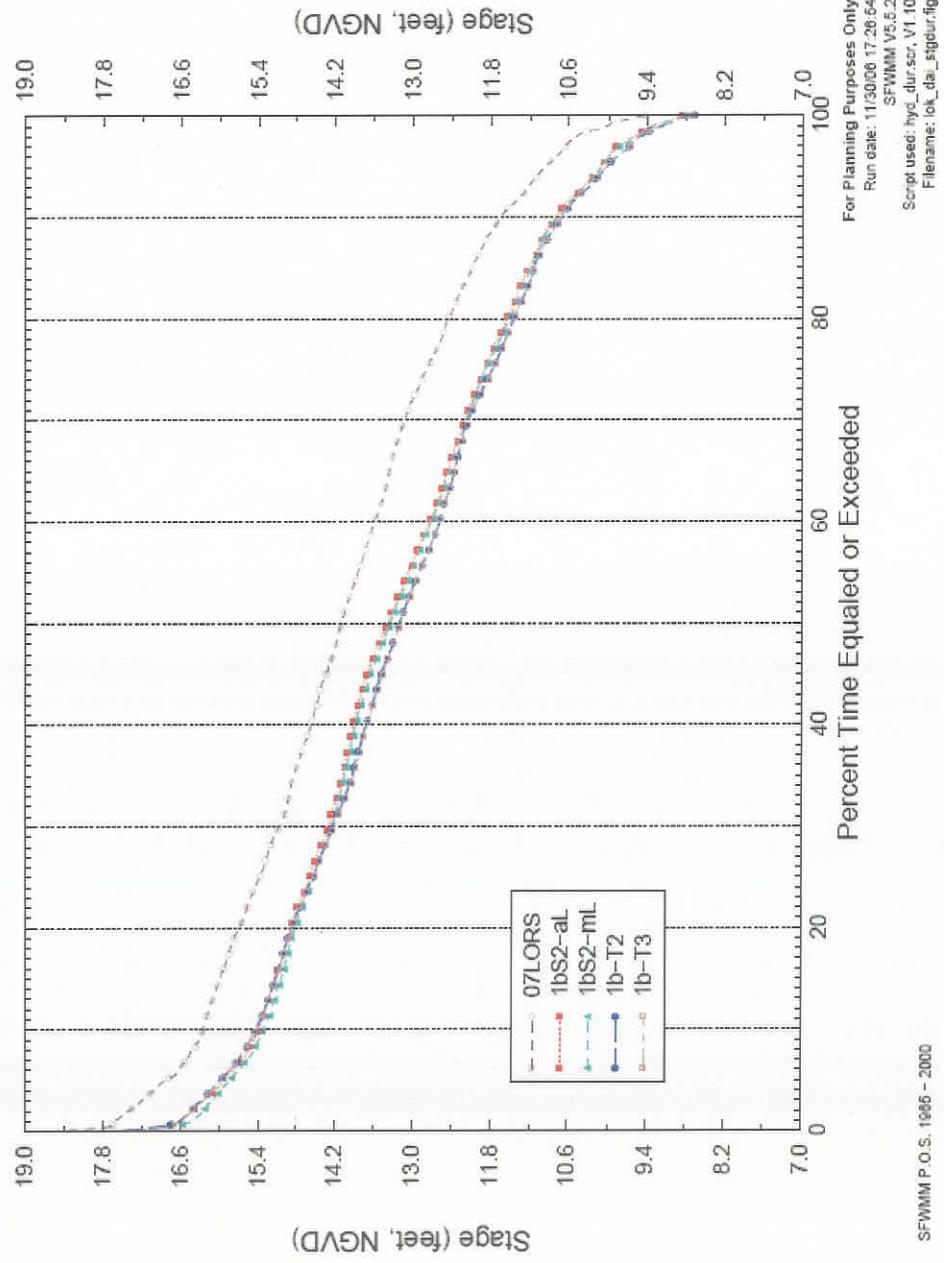


FIGURE C-3: LAKE OKEECHOBEE STAGE DURATION CURVES (1)

Stage Duration Curves for Lake Okeechobee

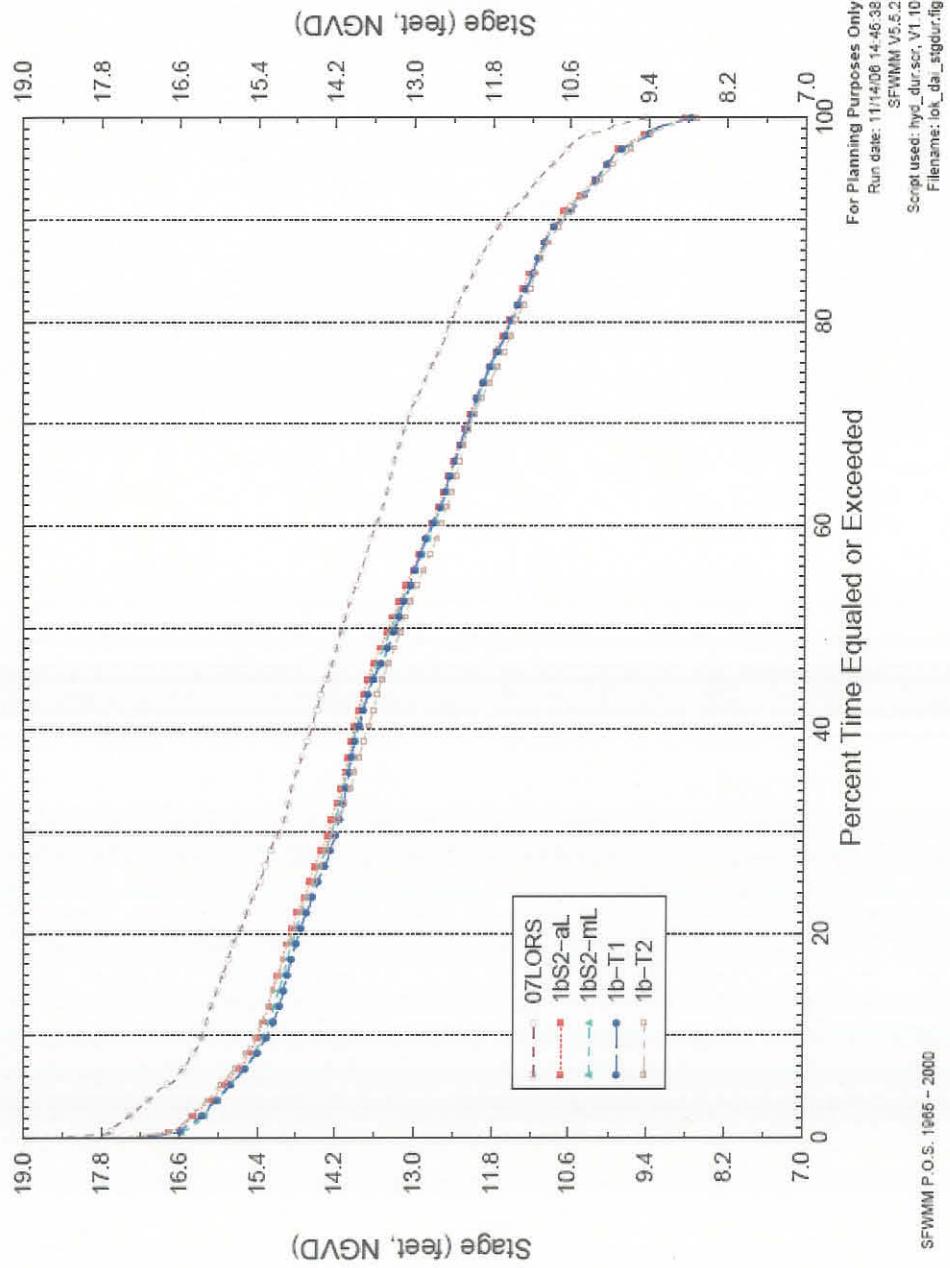


FIGURE C-4: LAKE OKEECHOBEE STAGE DURATION CURVES (2)

LORSS Lake Okeechobee Stage Duration Curves, Upper 10 Percentile

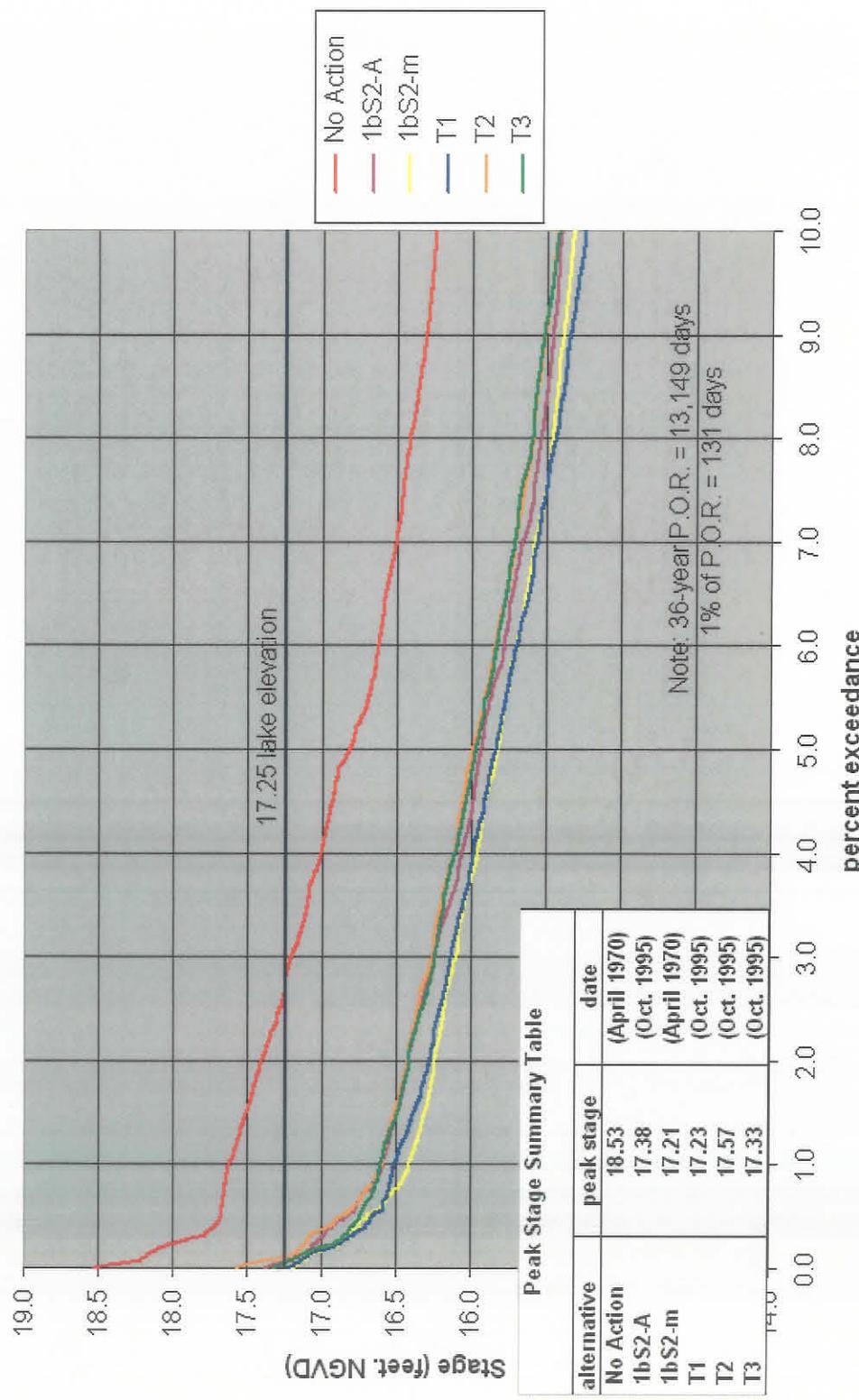


FIGURE C-5: LAKE OKEECHOBEE STAGE DURATION CURVES, UPPER 10 PERCENTILE

LORSS Lake Okeechobee Stage Duration Curves, Lower 40 Percentile

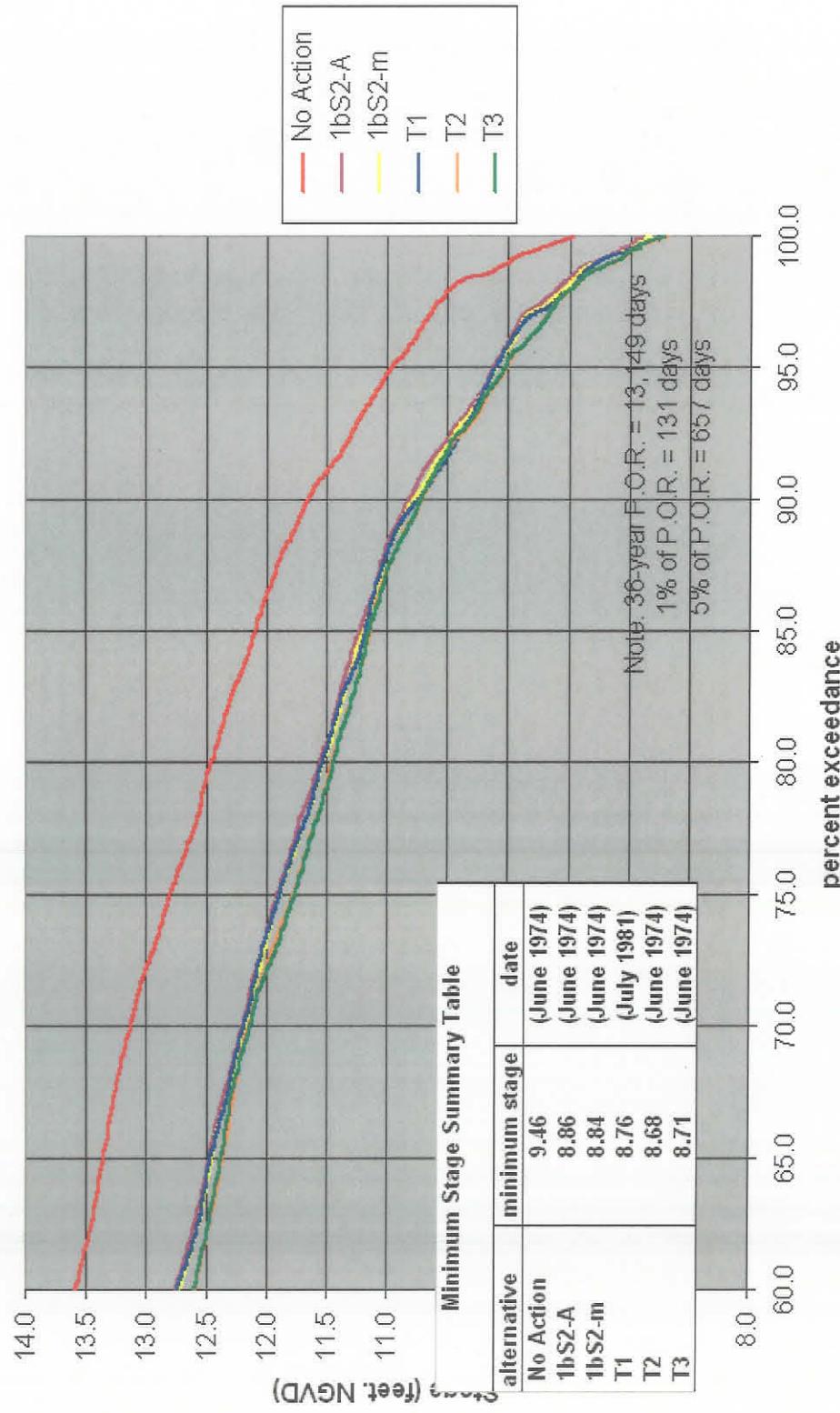


FIGURE C-6: LAKE OKEECHOBEE STAGE DURATION CURVES LOWER 40 PERCENTILE

**LORSS Summary of Lake Okeechobee High Stages (>16.00),
36-year simulated period-of-record**

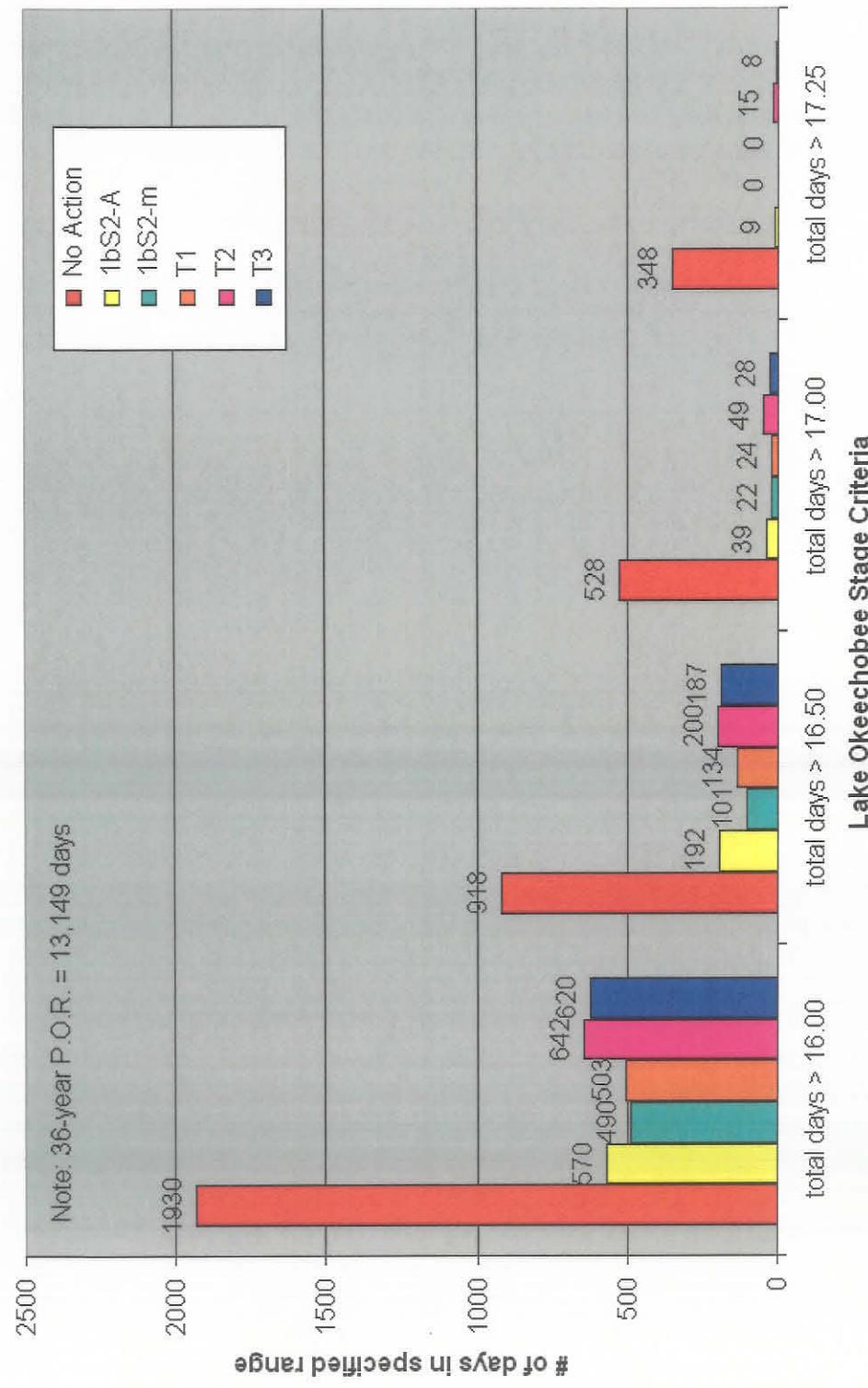
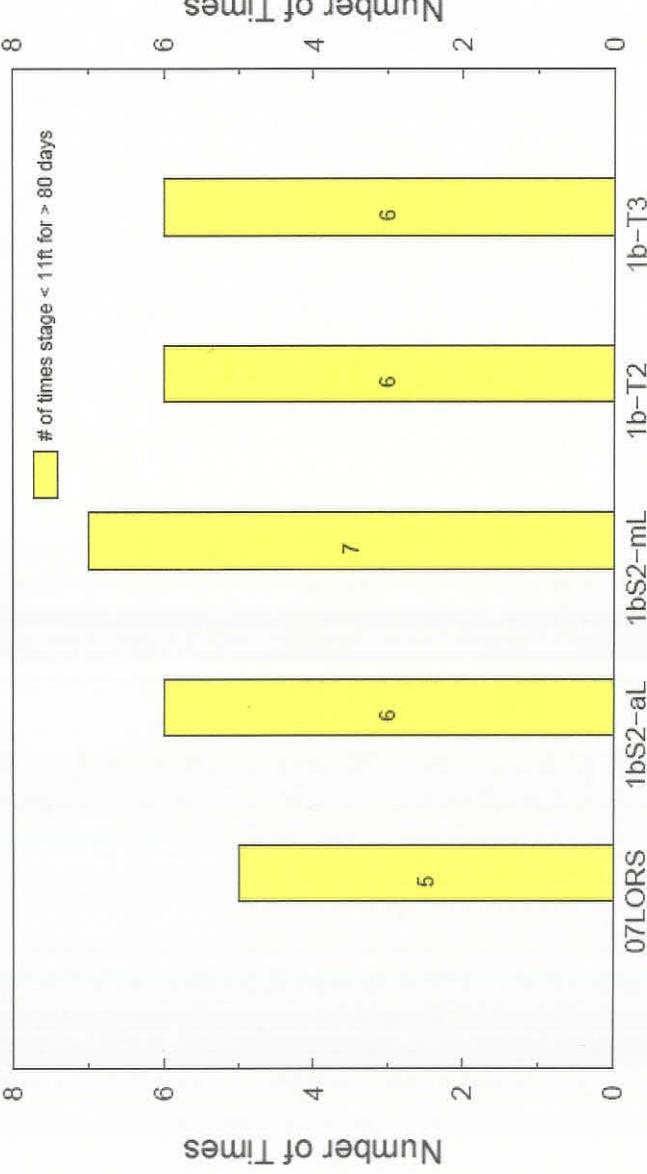


FIGURE C-7: OCCURRENCE FREQUENCY OF LAKE OKEECHOBEE HIGH STAGES

Number of Times LOK Proposed Minimum Water Level & Duration Criteria were Exceeded During the 1965–2000 Simulation

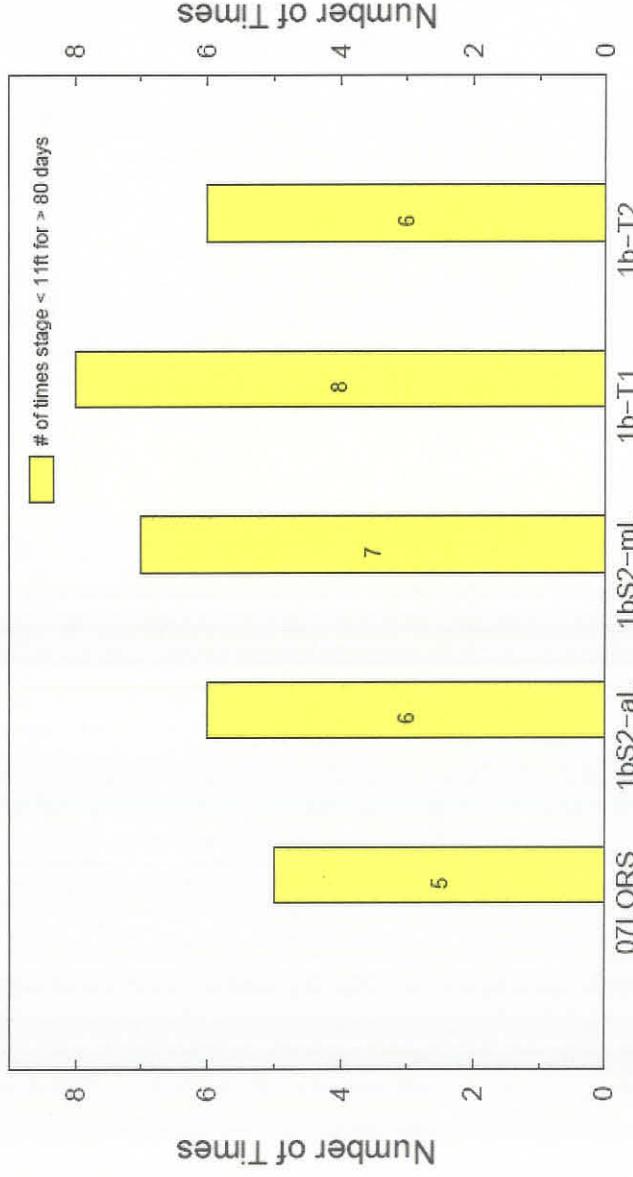
**Note:**

Target Minimum Level, duration and Return Frequency – Water levels in Lake Okeechobee should not fall below 11ft NGVD for greater than 80 days more often than once every six years (Target derived from 1932–1995 historical stage data for Lake Okeechobee).

For Planning Purposes Only
Run date: 11/30/06 17:34:39
SFWMW V5.6.2
Script used: loks_stage_events.ser, v1.3
Filename: loks_minhw_bar.fig

FIGURE C-8: NUMBER OF TIMES LAKE OKEECHOBEE MINIMUM WATER LEVEL AND DURATION CRITERIA WERE EXCEEDED DURING THE 1965-2000 SIMULATION (1)

Number of Times LOK Proposed Minimum Water Level & Duration Criteria were Exceeded During the 1965–2000 Simulation



Note:

Target: Minimum Level, duration and Return Frequency – Water levels in Lake Okeechobee should not fall below 11ft NGVD for greater than 80 days more often than once every six years (Target derived from 1952–1995 historical stage data for Lake Okeechobee).

For Planning Purposes Only
Run date: 11/14/06 14:51:39
SFWMW Version 5.2
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Filename: lOK_mininv_bar.rtg

FIGURE C-9: NUMBER OF TIMES LAKE OKEECHOBEE MINIMUM WATER LEVEL AND DURATION CRITERIA WERE EXCEEDED DURING THE 1965–2000 SIMULATION (2)

Daily Lake Okeechobee Stage Distribution: Alternative T3

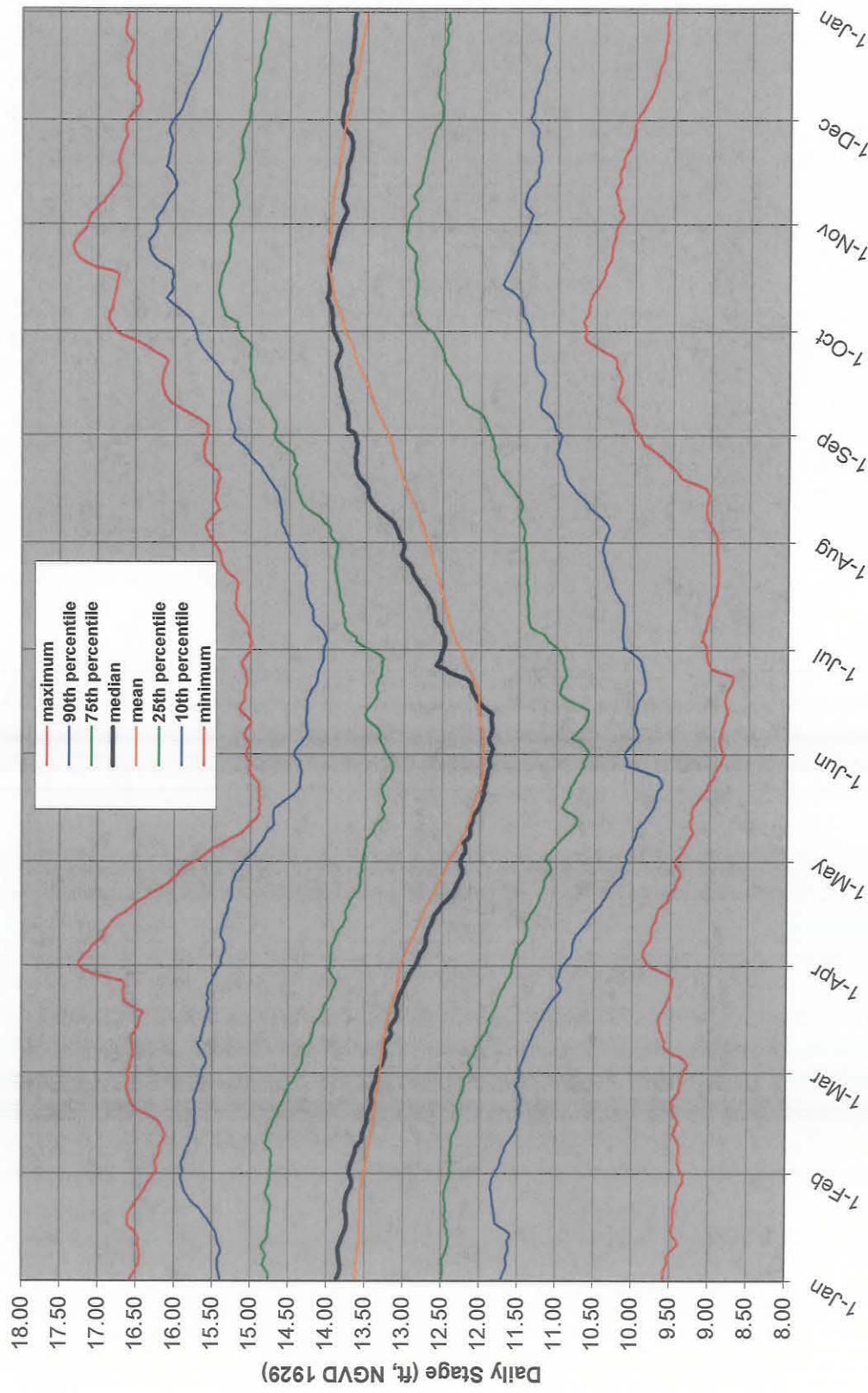


FIGURE C-10: LAKE OKEECHOBEE DAILY STAGE EXCEEDANCE CURVES FOR ALTERNATIVE T3

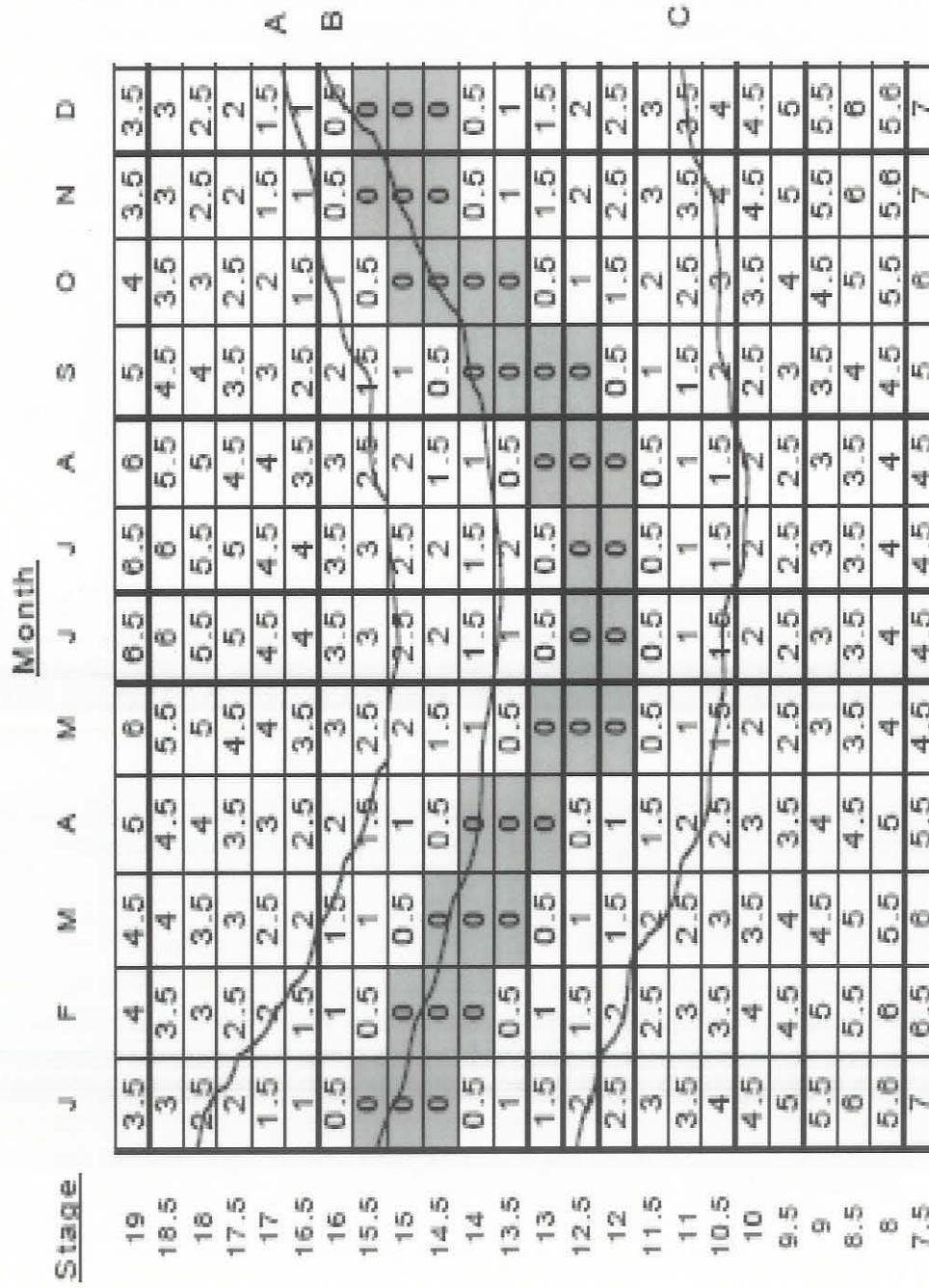


FIGURE C-11: CONCEPTUALIZATION OF LAKE OKEECHOBEE STAGE ENVELOPE PERFORMANCE MEASURE

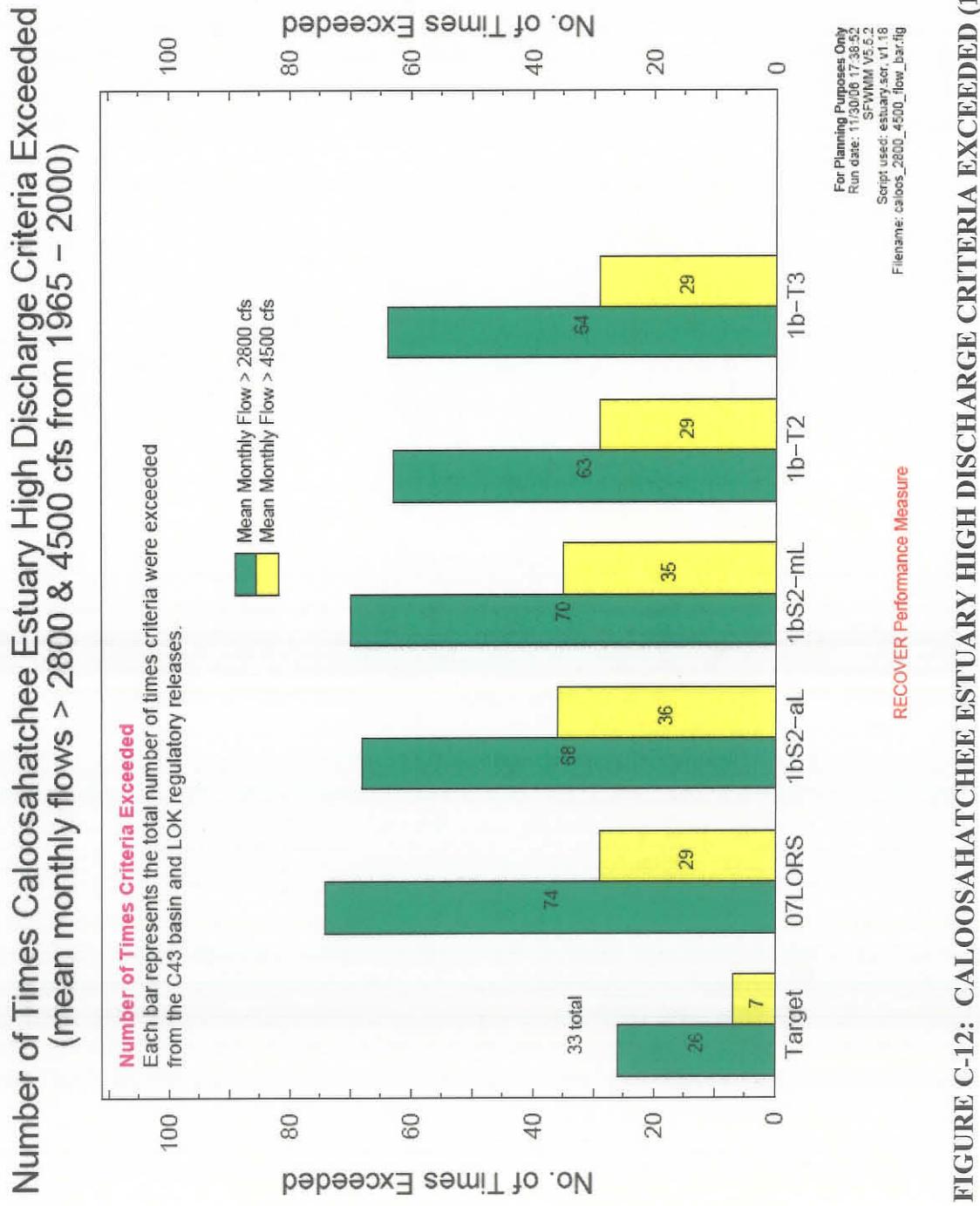


FIGURE C-12: CALOOSAHAATCHEE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (1)

Number of Times Caloosahatchee Estuary High Discharge Criteria Exceeded (mean monthly flows > 2800 & 4500 cfs from 1965 – 2000)

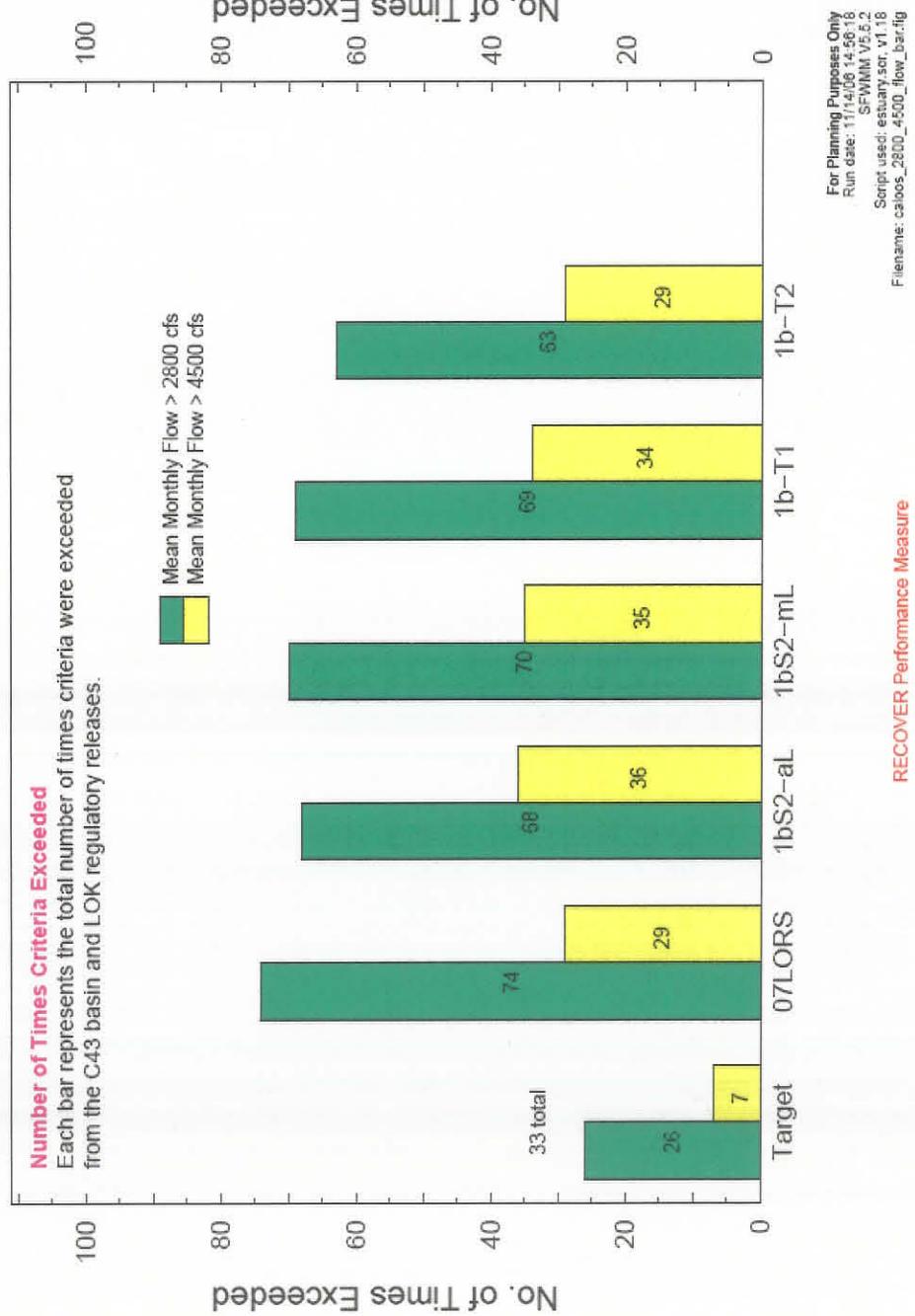


FIGURE C-13: CALOOSAHAATCHEE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (2)

Number of times Salinity Envelope Criteria NOT Met for the Caloosahatchee Estuary (mean monthly flows 1965 – 2000)

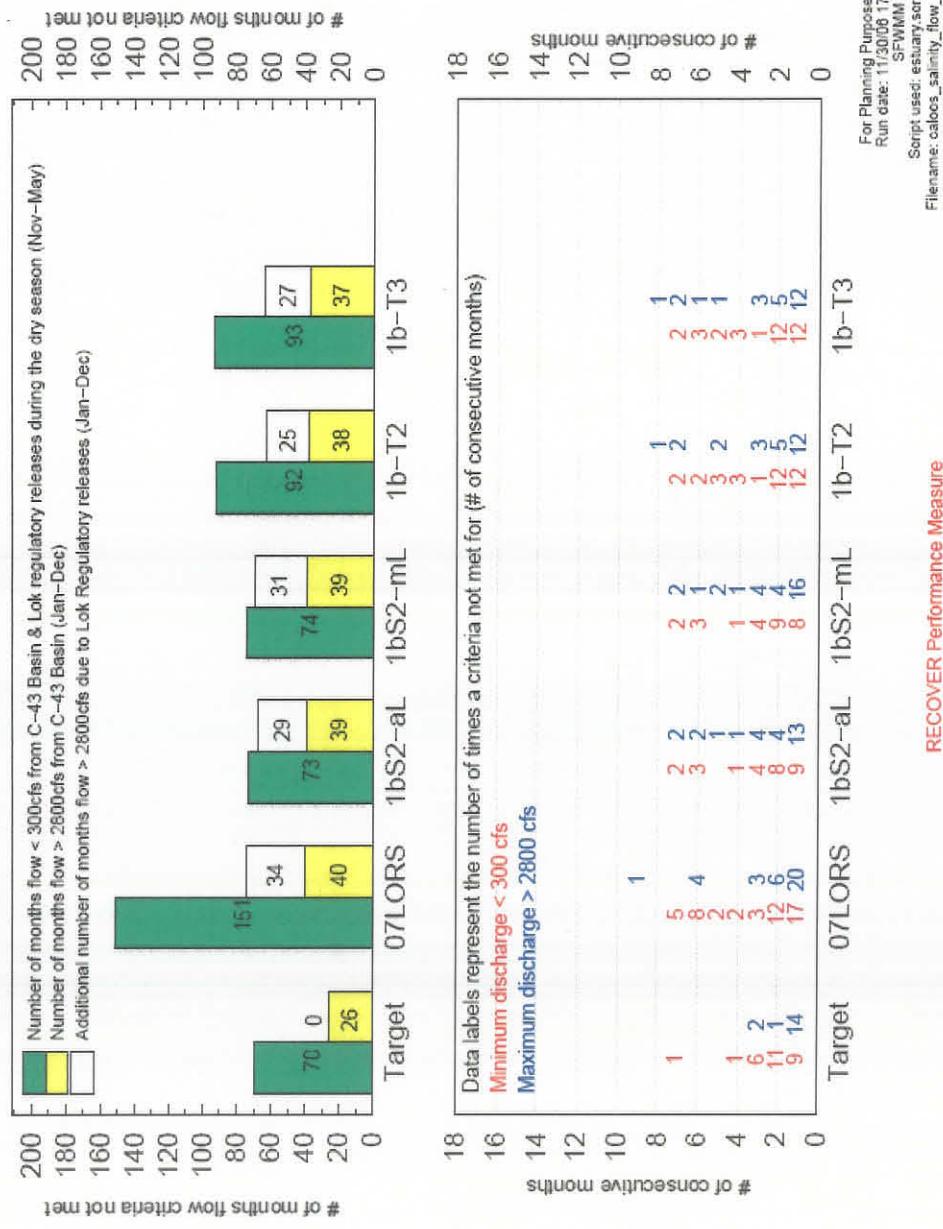


FIGURE C-14: CALOOSA HATCHEE ESTUARY SALINITY ENVELOPE CRITERIA (1)

Number of times Salinity Envelope Criteria NOT Met for the Caloosahatchee Estuary (mean monthly flows 1965 – 2000)

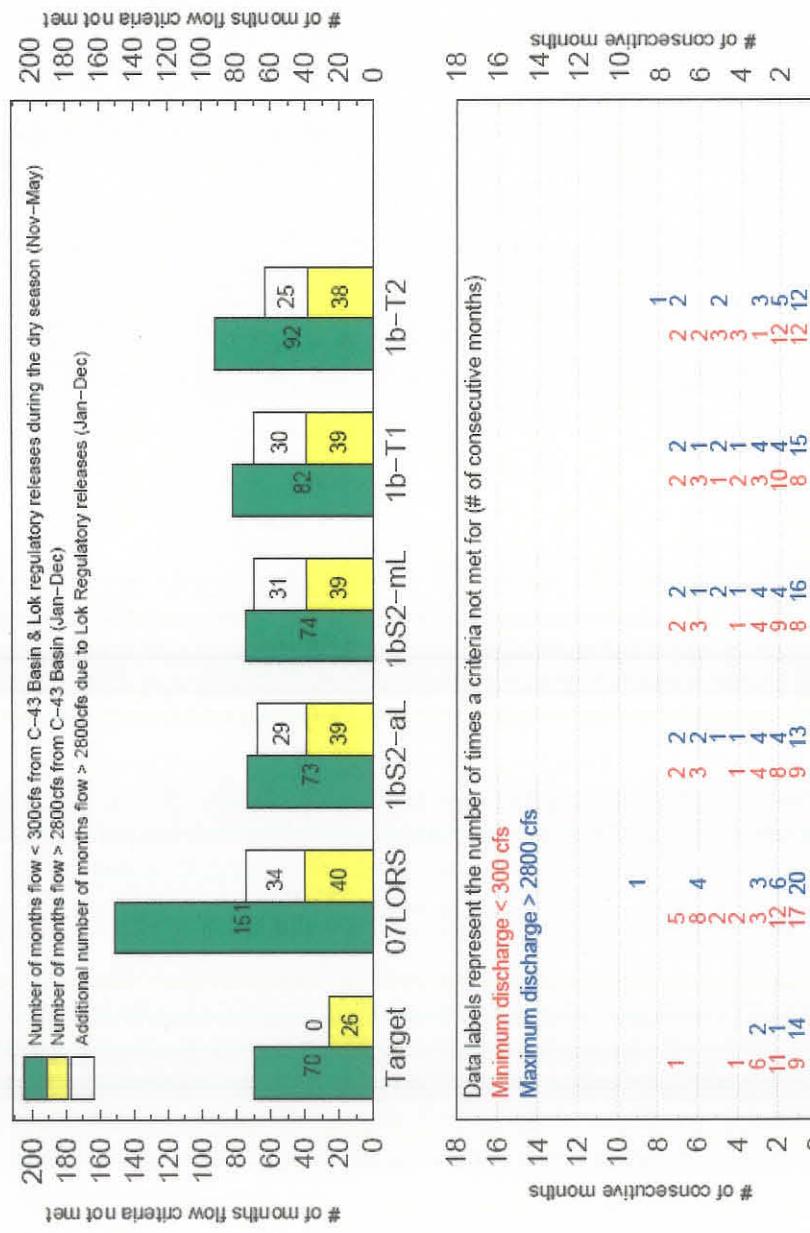
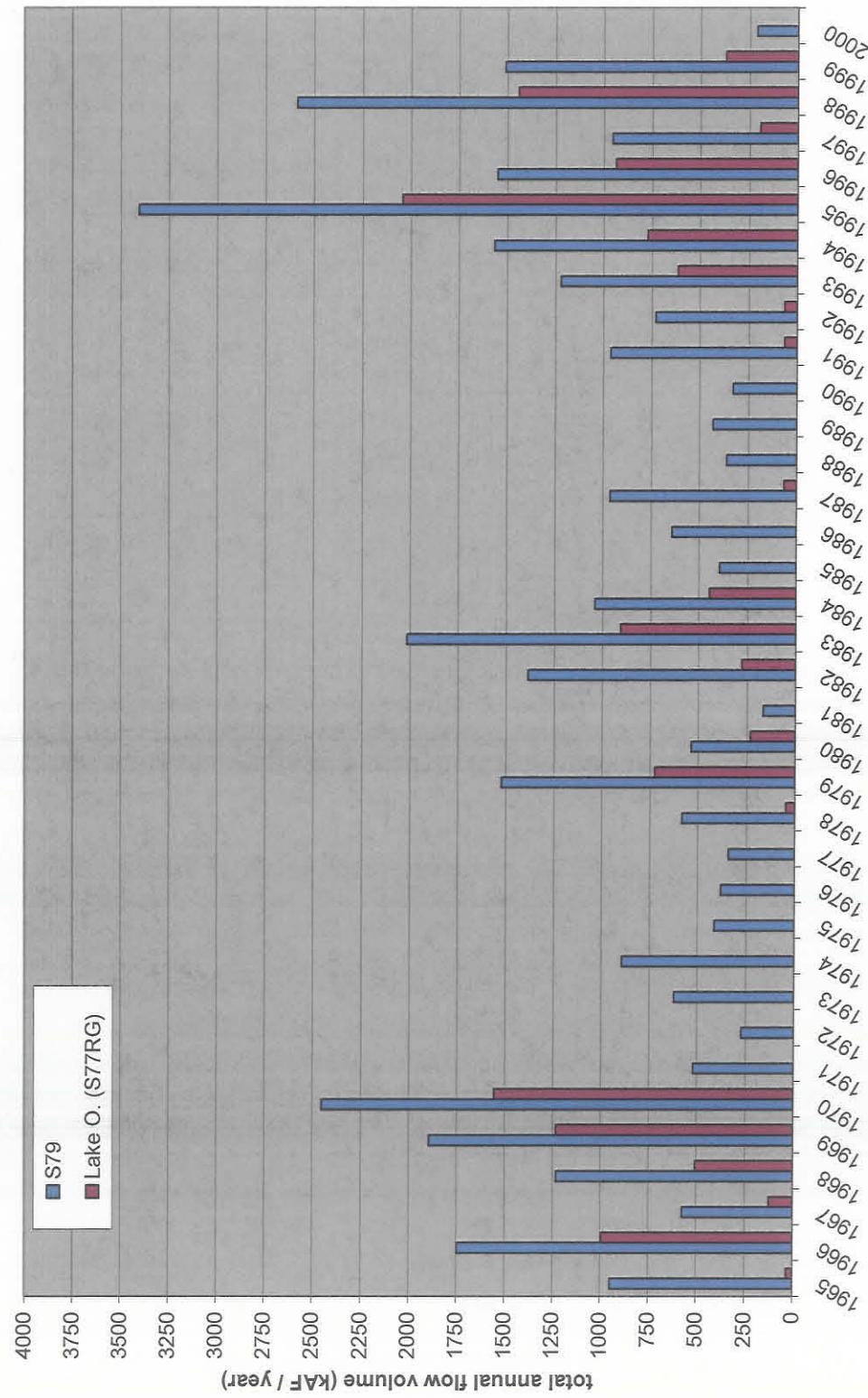
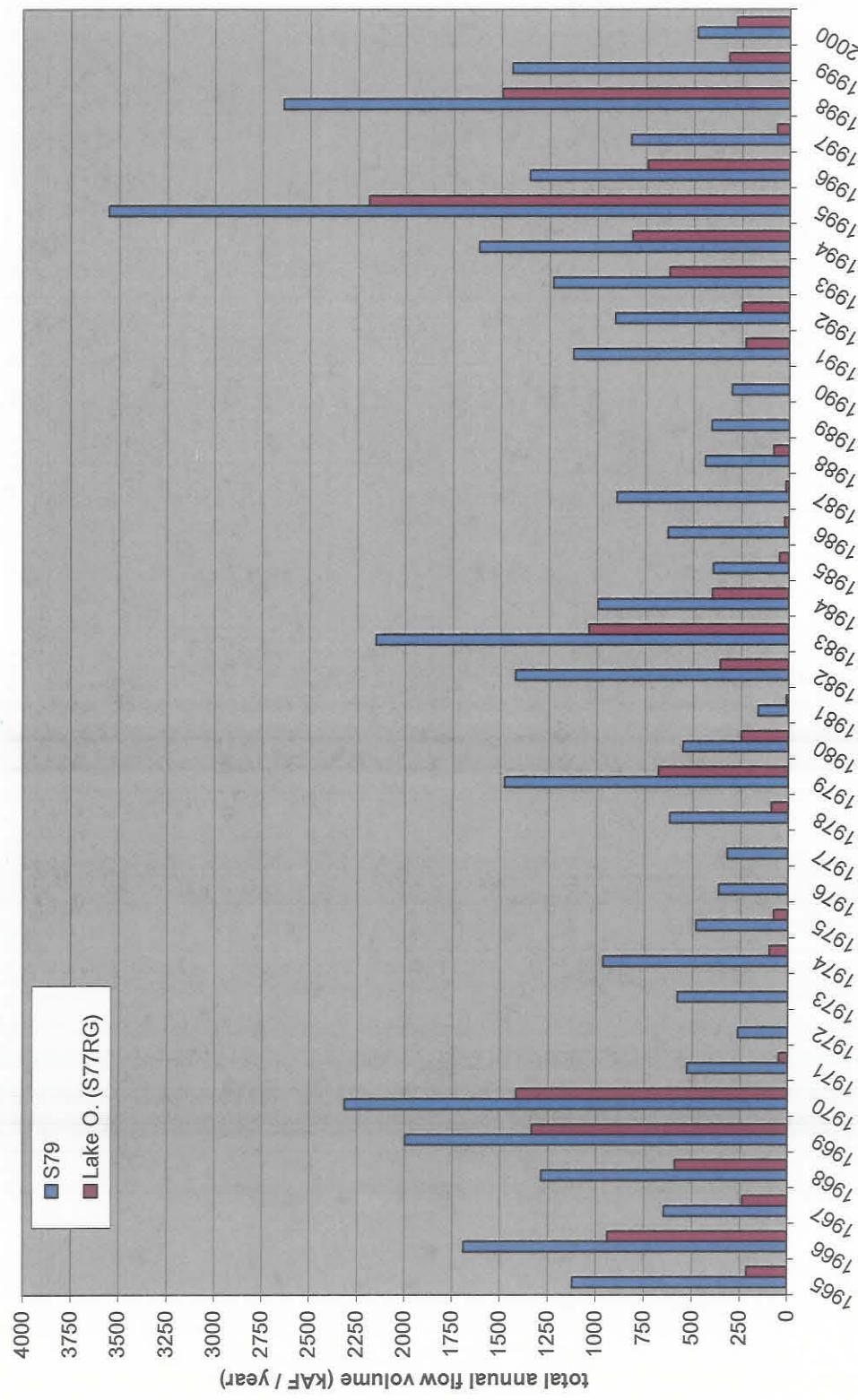


FIGURE C-15: CALOOSA HATCHEE ESTUARY SALINITY ENVELOPE CRITERIA (2)

Annual Distribution of Flows to Caloosahatchee River Estuary: No Action Alternative



**FIGURE C-16: ANNUAL DISTRIBUTION OF FLOWS TO THE CALOOSA HATCHEE ESTUARY,
NO ACTION ALTERNATIVE**

Annual Distribution of Flows to Caloosahatchee River Estuary: Alternative T3

**FIGURE C-17: ANNUAL DISTRIBUTION OF FLOWS TO THE CALOOSA HATCHEE ESTUARY,
ALTERNATIVE T3**

Seasonal Distribution of Flows to Caloosahatchee River Estuary: No Action Alternative

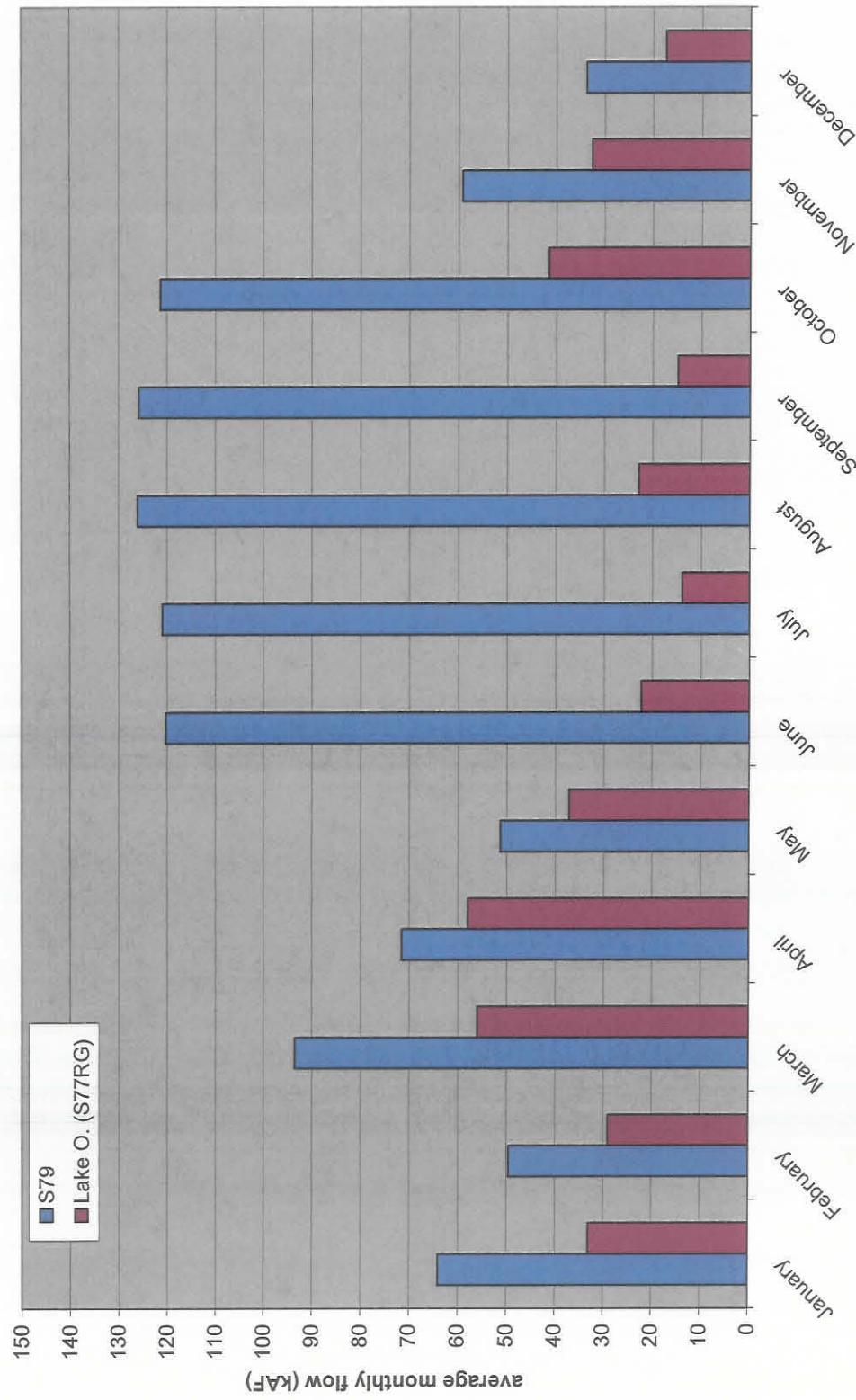


FIGURE C-18: SEASONAL DISTRIBUTION OF FLOWS TO THE CALOOSA HATCHEE ESTUARY,
NO ACTION ALTERNATIVE

Seasonal Distribution of Flows to Caloosahatchee River Estuary: Alternative T3

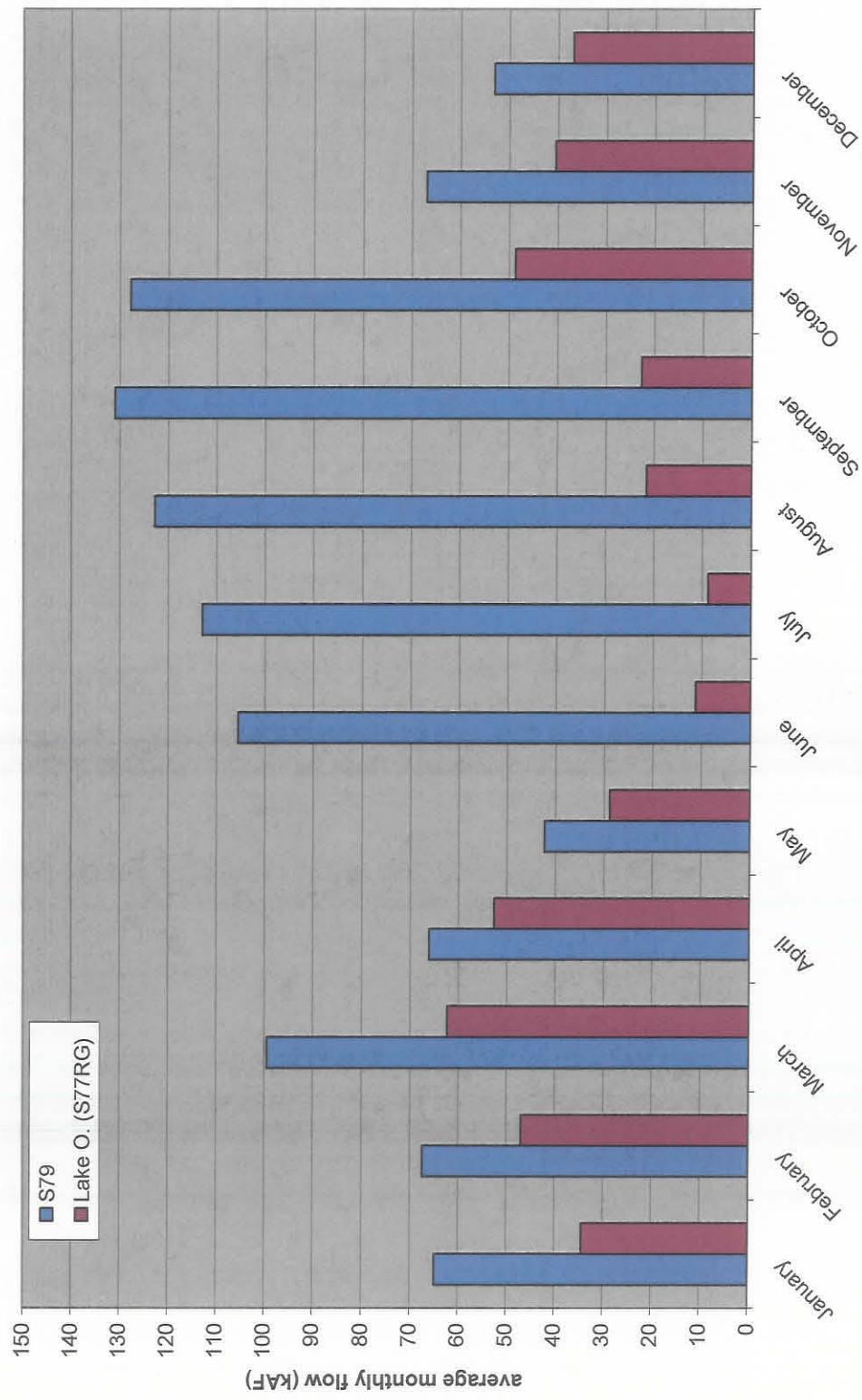


FIGURE C-19: SEASONAL DISTRIBUTION OF FLOWS TO THE CALOOSA HATCHEE ESTUARY,
ALTERNATIVE T3

Number of Times St. Lucie High Discharge Criteria Exceeded (mean monthly flows > 2000 cfs from 1965 – 2000)

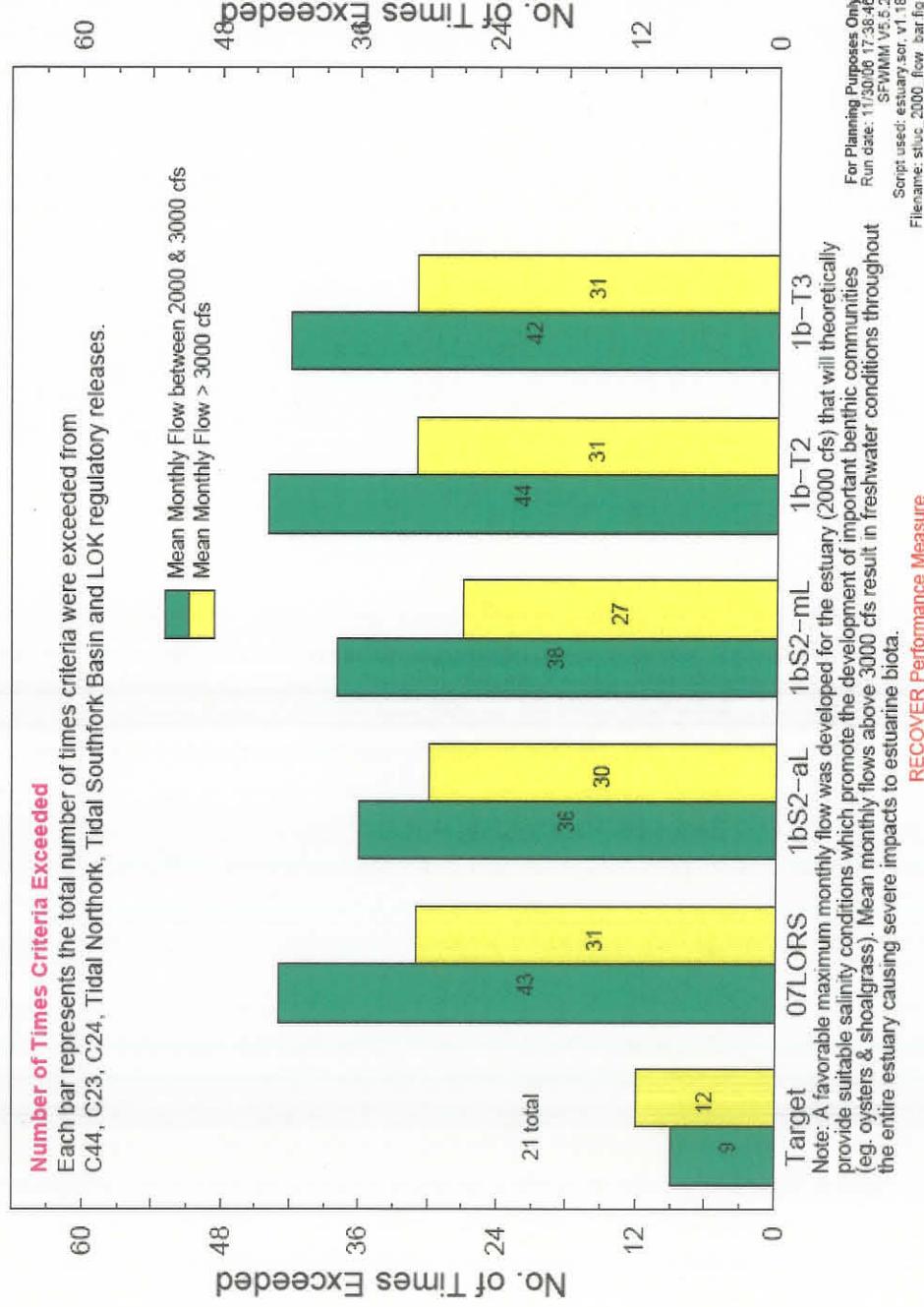


FIGURE C-20: ST. LUCIE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (1)

Number of Times St. Lucie High Discharge Criteria Exceeded (mean monthly flows > 2000 cfs from 1965 – 2000)

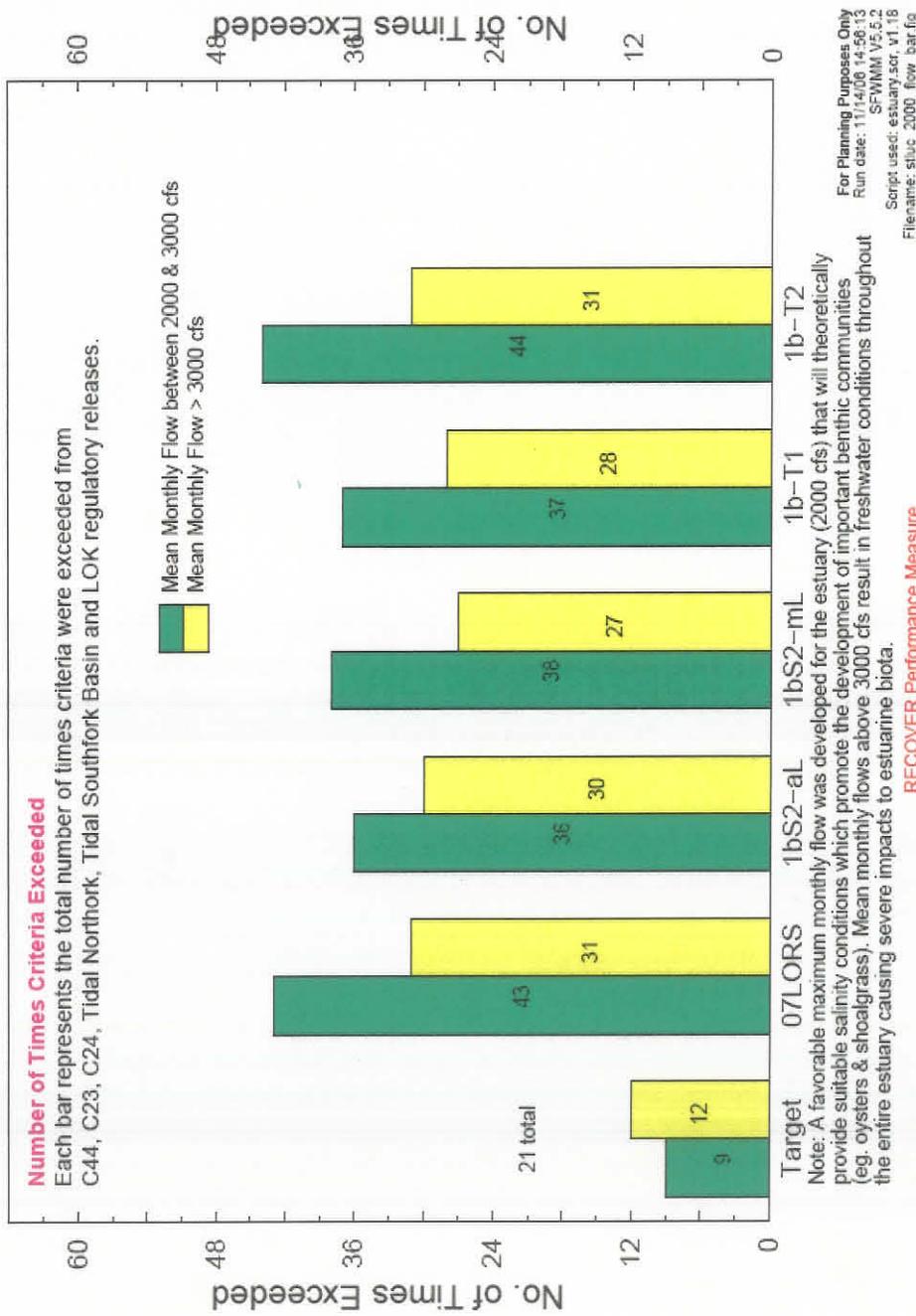
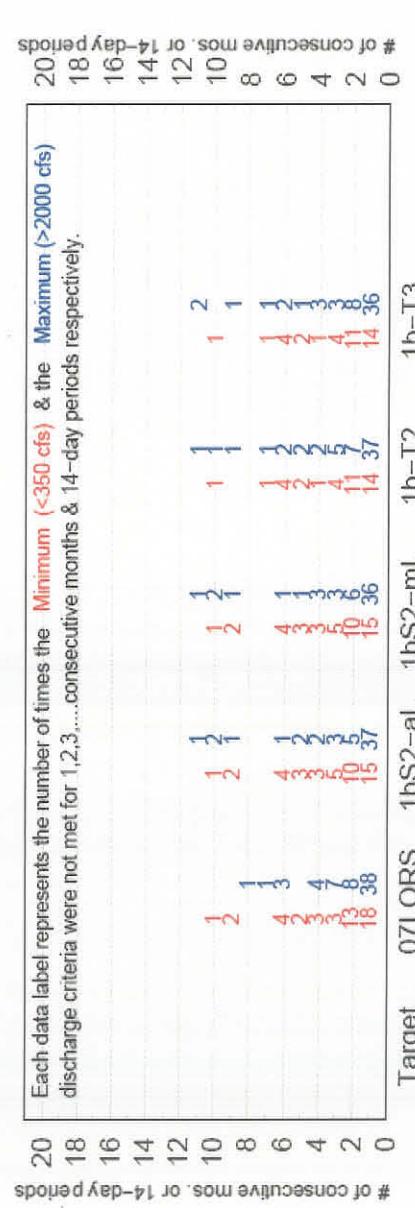
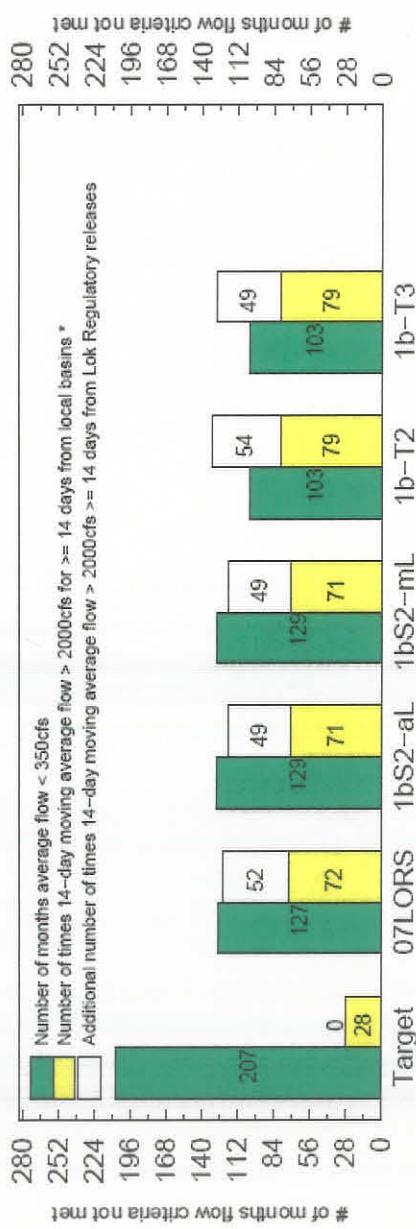


FIGURE C-21: ST. LUCIE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (2)

Number of times Salinity Envelope Criteria NOT Met for the St. Lucie Estuary (mean monthly flows 1965 – 2000)

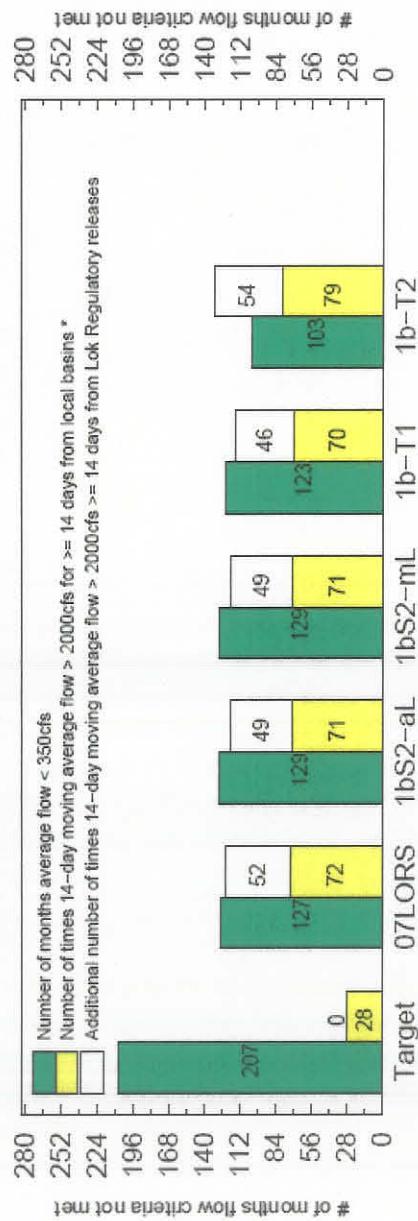


Each data label represents the number of times the **Minimum (<350 cfs)** & the **Maximum (>2000 cfs)** discharge criteria were not met for 1,2,3,...consecutive months & 14-day periods respectively.

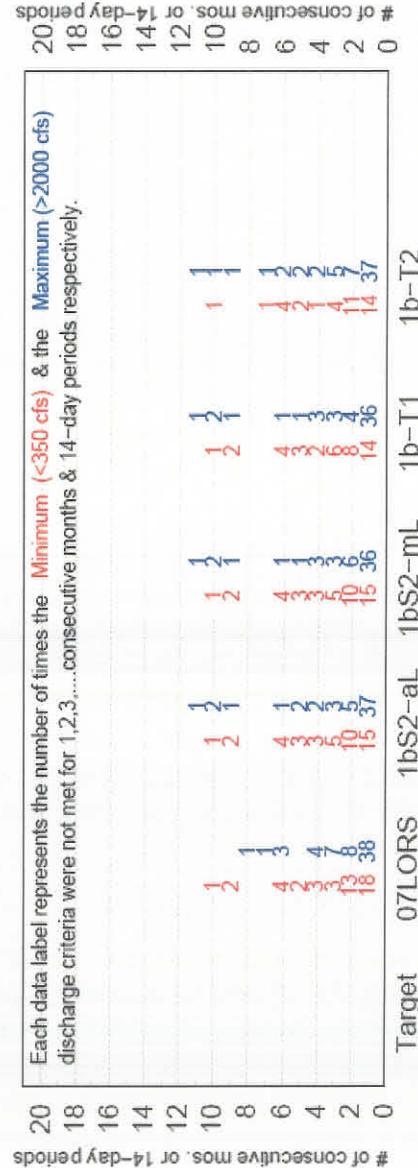
For Planning Purposes Only
Run Date: 11/30/08 17:38:44
Script used: estuary.scr v1.18
Filename: stluc_salinity_flow_bar.fg

FIGURE C-22: ST. LUCIE ESTUARY SALINITY ENVELOPE CRITERIA (1)

Number of times Salinity Envelope Criteria NOT Met for the St. Lucie Estuary (mean monthly flows 1965 – 2000)



Each data label represents the number of times the **Minimum (<350 cfs)** & the **Maximum (>2000 cfs)** discharge criteria were not met for 1,2,3,...consecutive months & 14-day periods respectively.

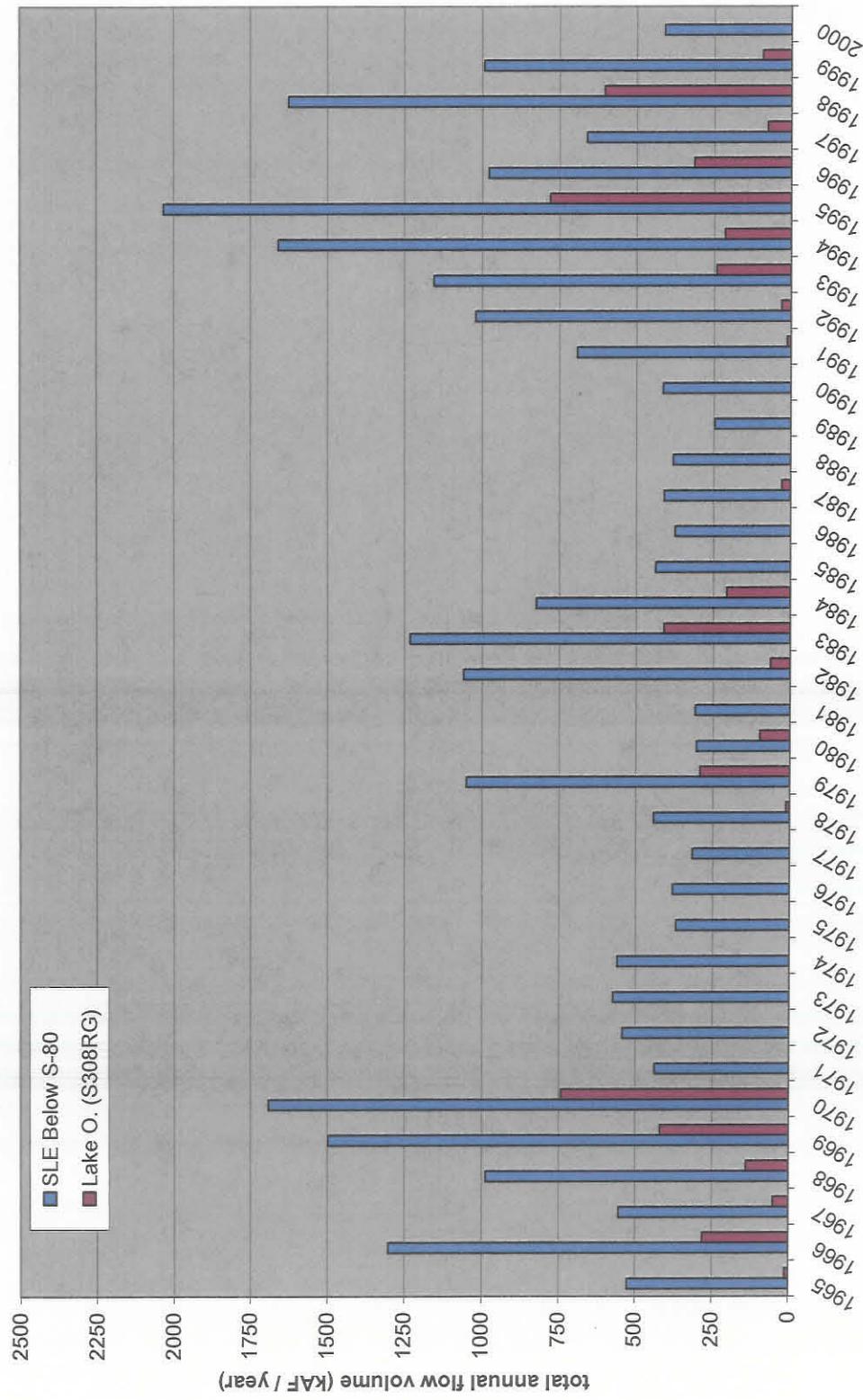


For Planning Purposes Only
Run Date: 11/14/06 14:58:11
SFWMM V5.5.2
Script used: estuan.scr, v1.18
Filename: stuc_salinity_flow_bar.fig

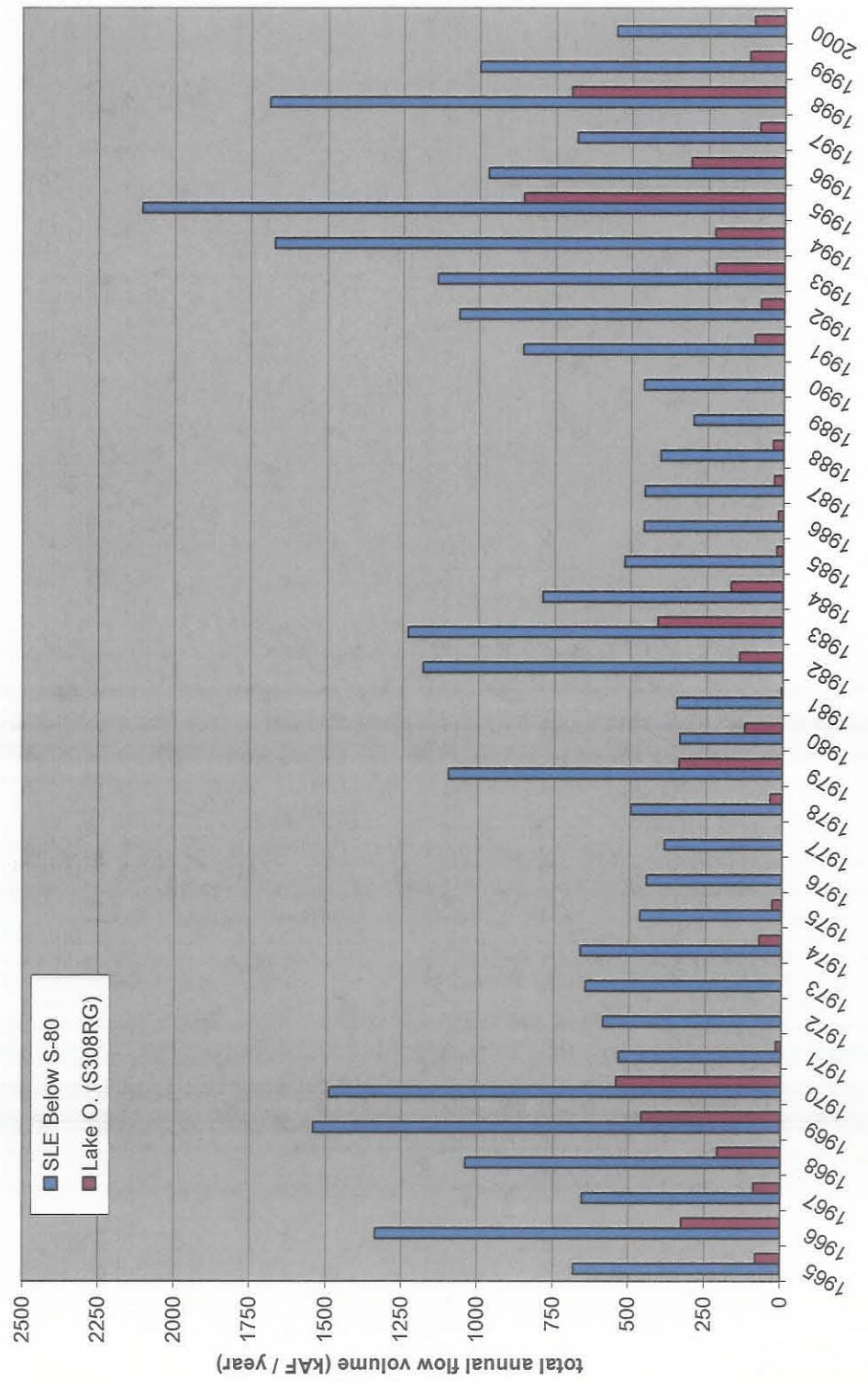
RECOVER Performance Measure

FIGURE C-23: ST. LUCIE ESTUARY SALINITY ENVELOPE CRITERIA (2)

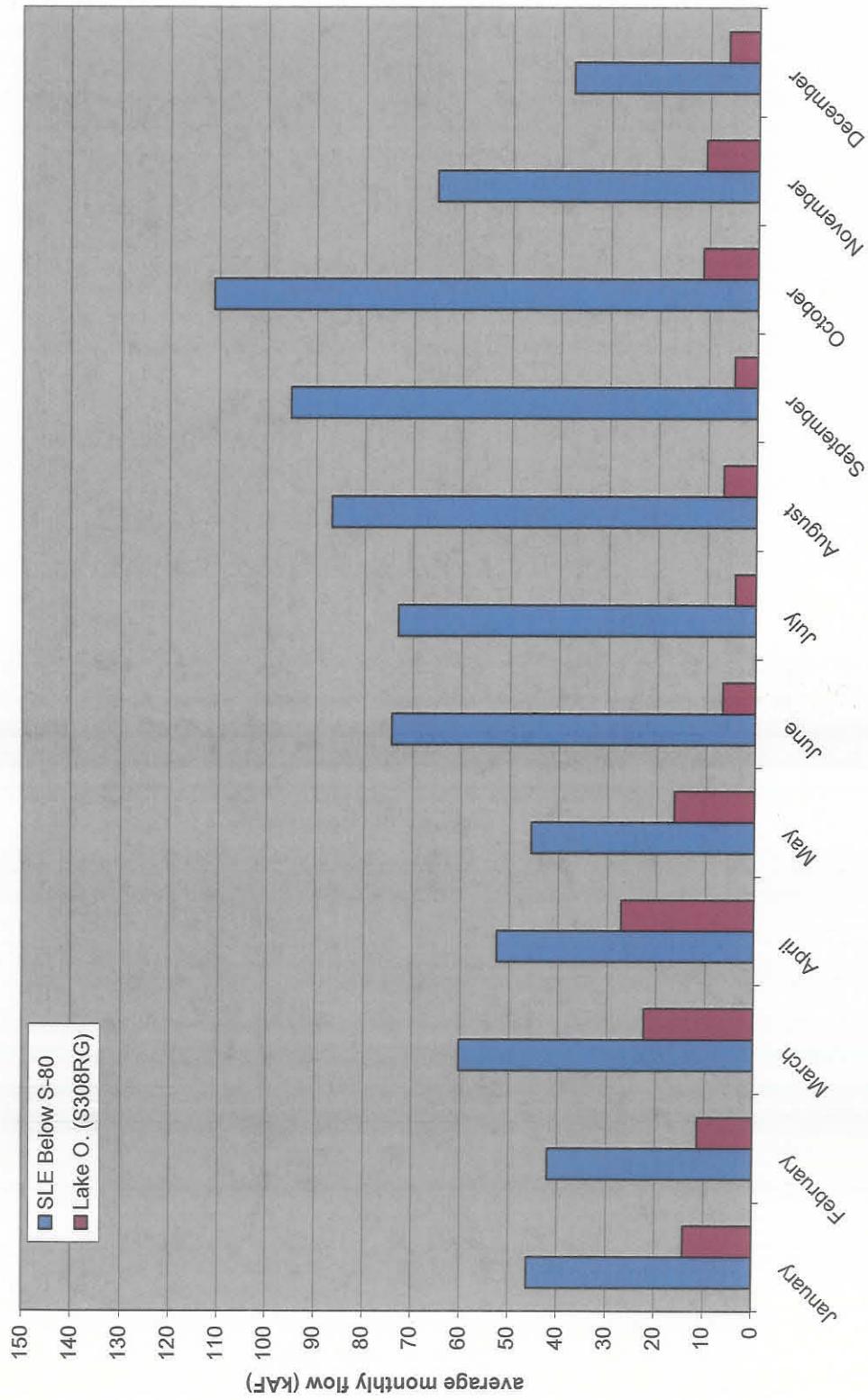
Annual Distribution of Flows to St. Lucie Estuary: No Action Alternative



**FIGURE C-24: ANNUAL DISTRIBUTION OF FLOWS TO THE ST. LUCIE ESTUARY,
NO ACTION ALTERNATIVE**

Annual Distribution of Flows to St. Lucie Estuary: Alternative T3

**FIGURE C-25: ANNUAL DISTRIBUTION OF FLOWS TO THE ST. LUCIE ESTUARY,
ALTERNATIVE T3**

Seasonal Distribution of Flows to St. Lucie Estuary: No Action Alternative

**FIGURE C-26: SEASONAL DISTRIBUTION OF FLOWS TO THE ST. LUCIE ESTUARY,
NO ACTION ALTERNATIVE**

Seasonal Distribution of Flows to St. Lucie Estuary: Alternative T3

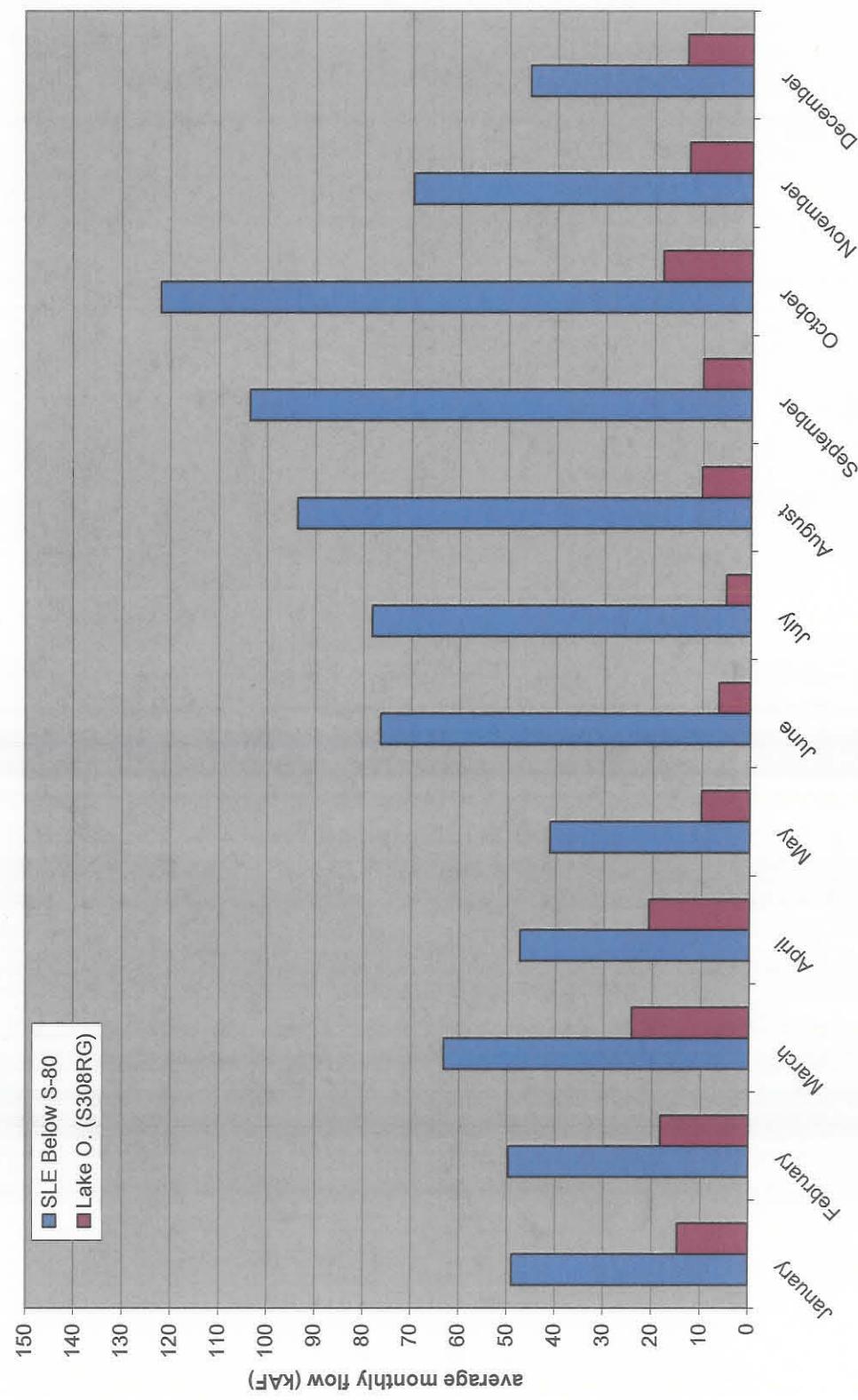
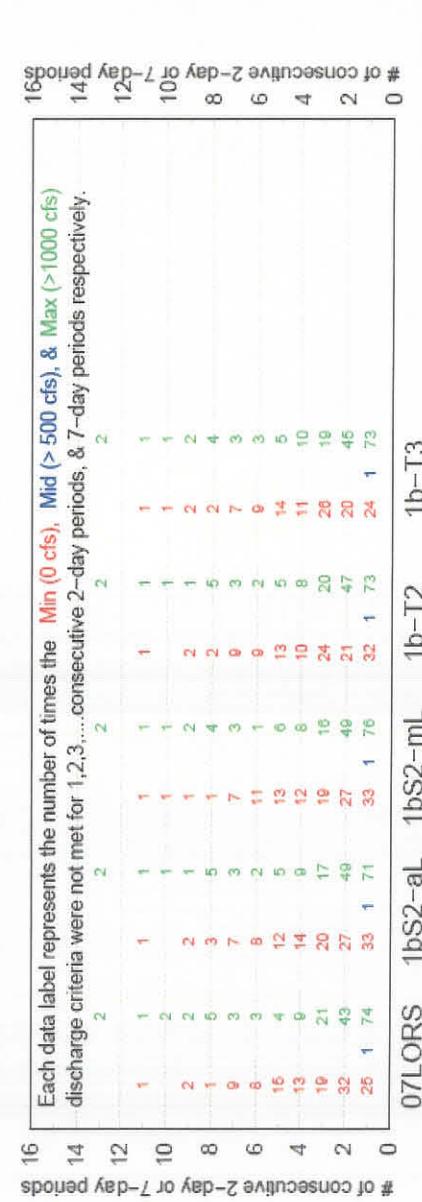
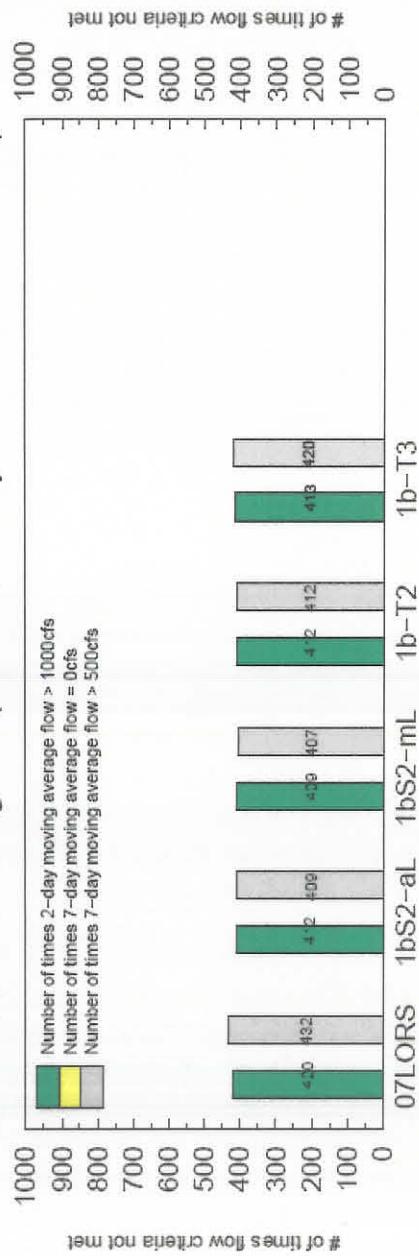


FIGURE C-27: SEASONAL DISTRIBUTION OF FLOWS TO THE ST. LUCIE ESTUARY,
ALTERNATIVE T3

Number of times Salinity Envelope Criteria were NOT met for Lake Worth Lagoon (mean monthly flows 1965 - 2000)



Each data label represents the number of times the **Min (0 cfs)**, **Mid (>500 cfs)**, & **Max (>1000 cfs)** discharge criteria were not met for 1,2,3,...consecutive 2-day periods, & 7-day periods respectively.

of consecutive 2-day or 7-day periods

For Planning Purposes Only
Run date: 11/30/06 17:30:28
SWMM V5.6.2
Server used: estuary.svr v1.18
Filename: lkworth_salinity_flow_bar.fig

FIGURE C-28: LAKE WORTH LAGOON SALINITY ENVELOPE CRITERIA (1)

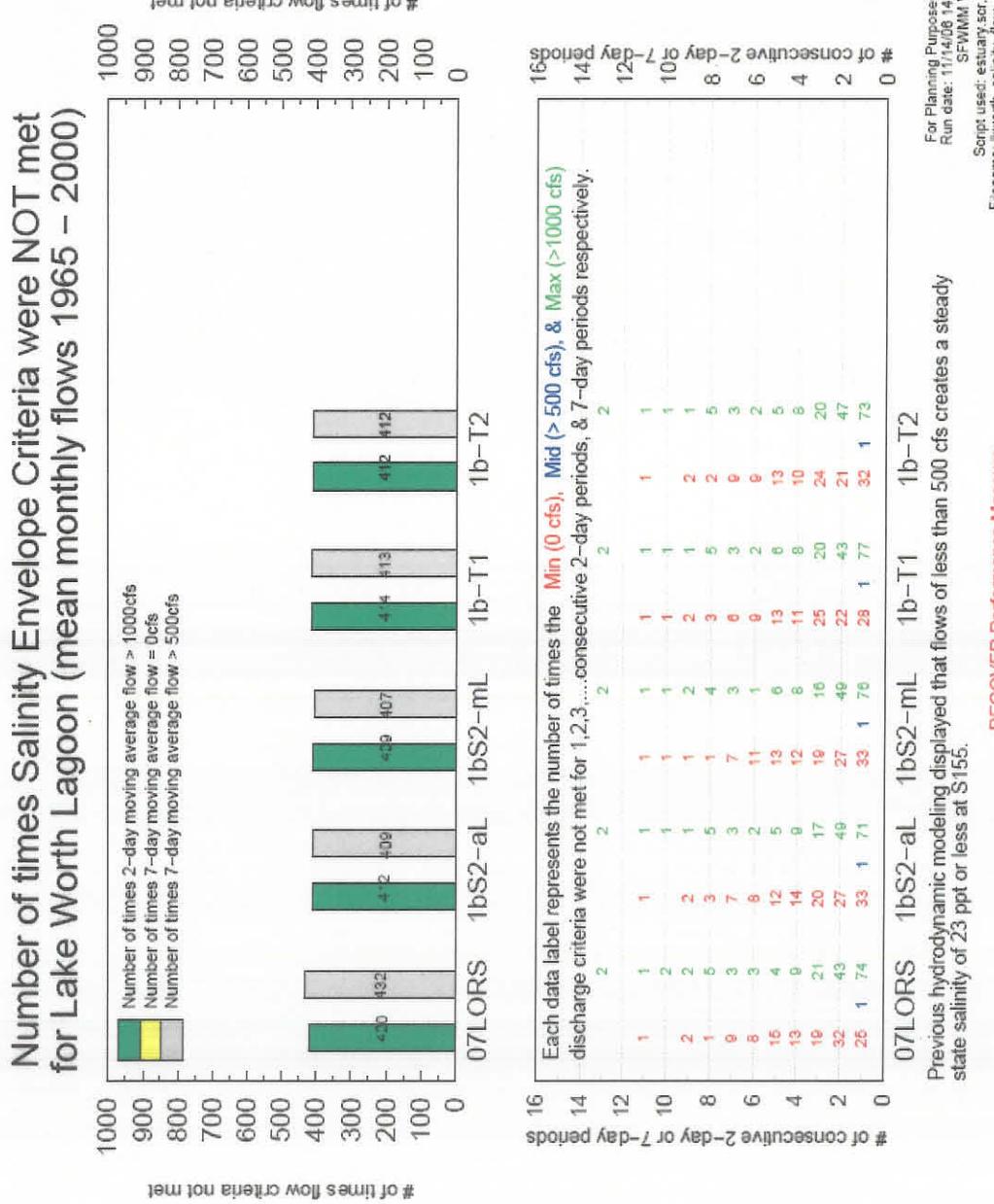


FIGURE C-29: LAKE WORTH LAGOON SALINITY ENVELOPE CRITERIA (2)

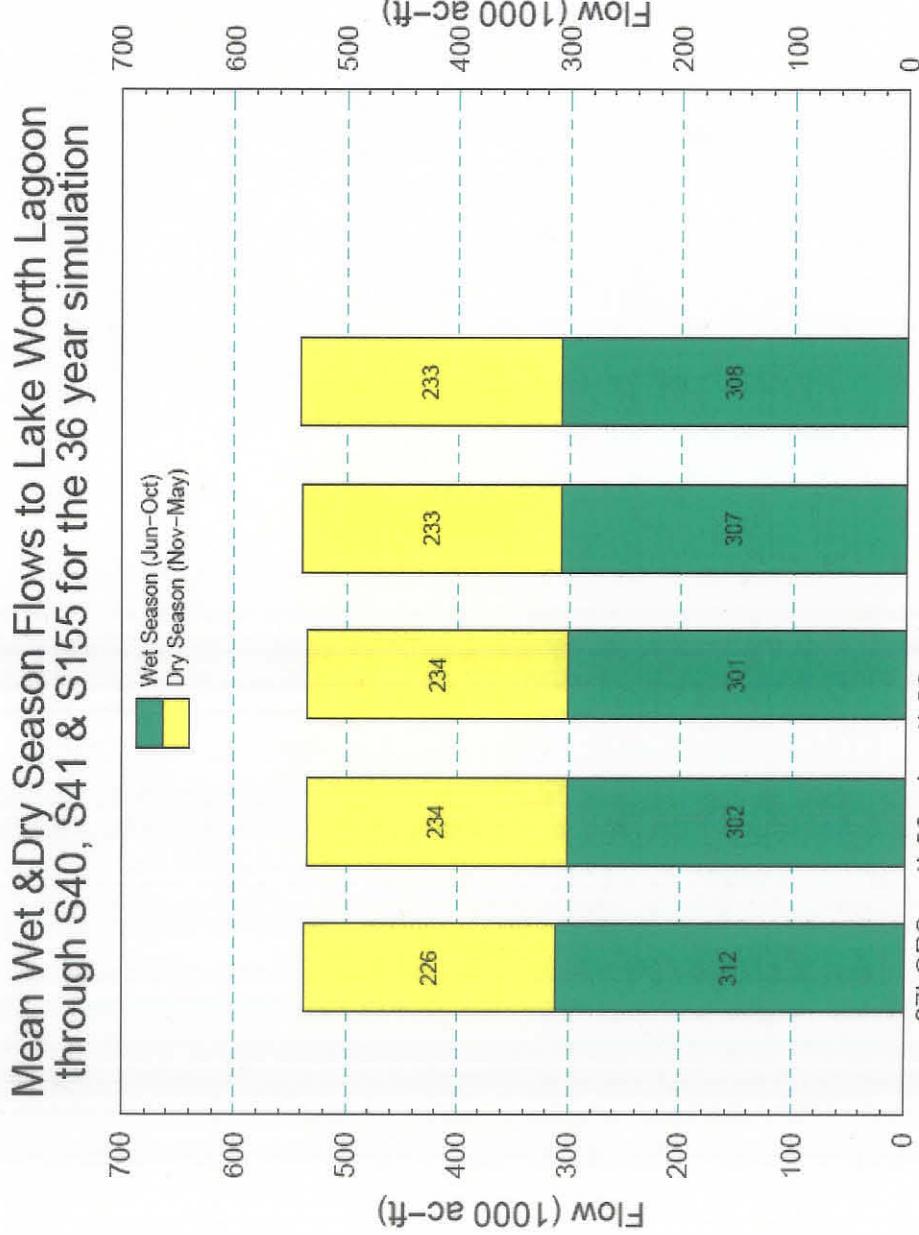


FIGURE C-30: LAKE WORTH LAGOON, MEAN WET AND DRY SEASON FLOWS (1)

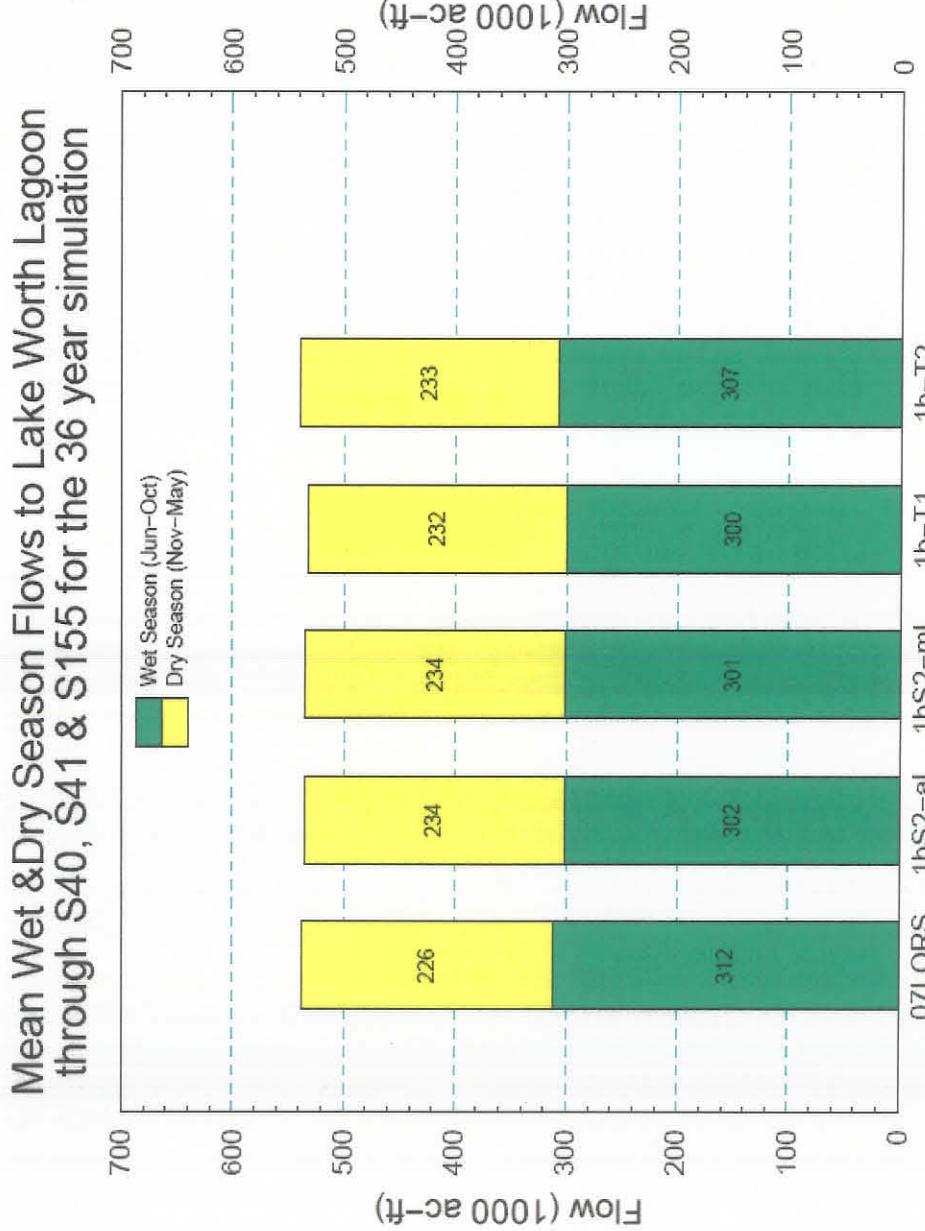


FIGURE C-31: LAKE WORTH LAGOON, MEAN WET AND DRY SEASON FLOWS (2)

Simulated Mean Seasonal Structure Flows Discharged into Biscayne Bay for 1965 – 2000

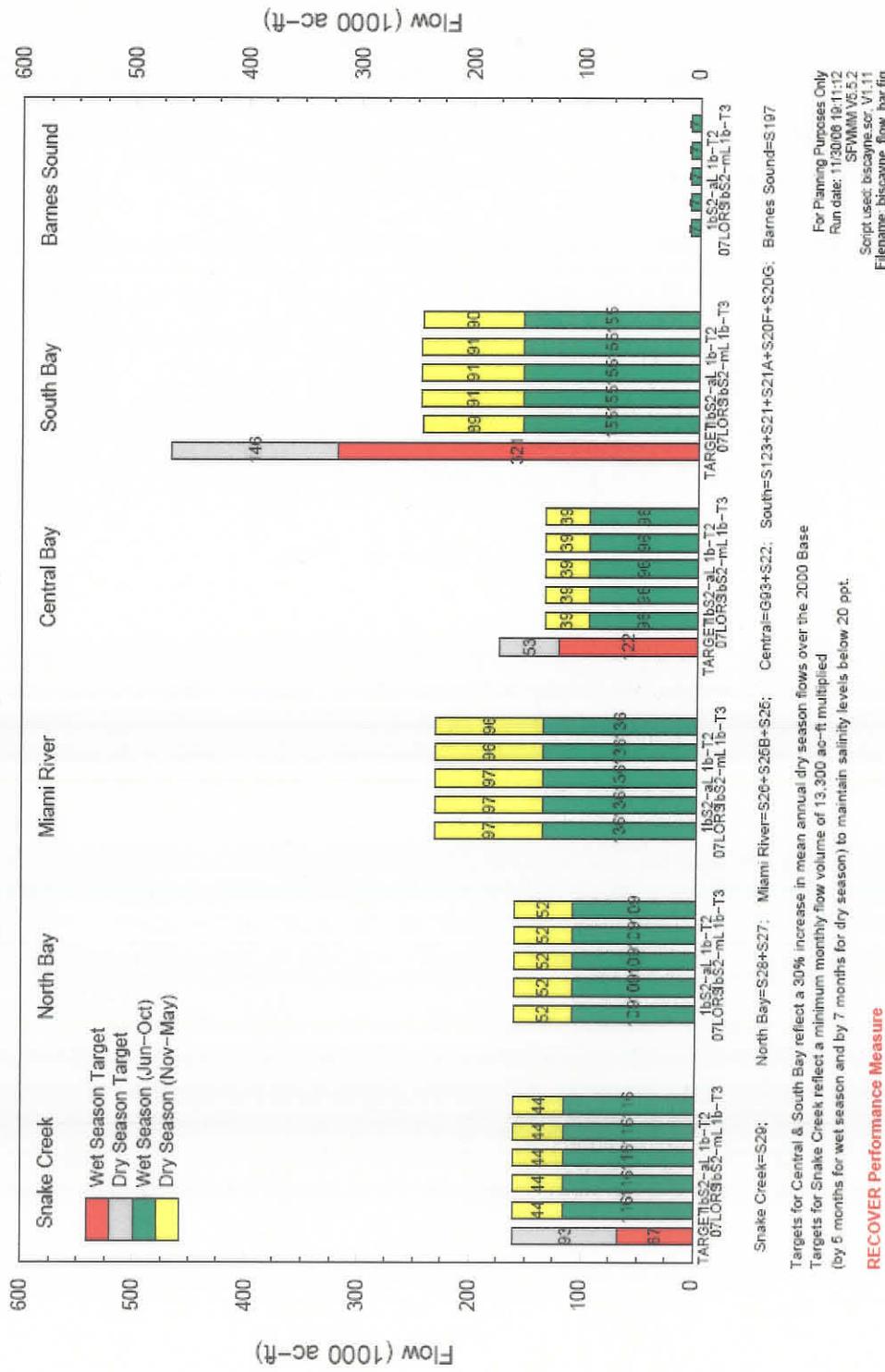
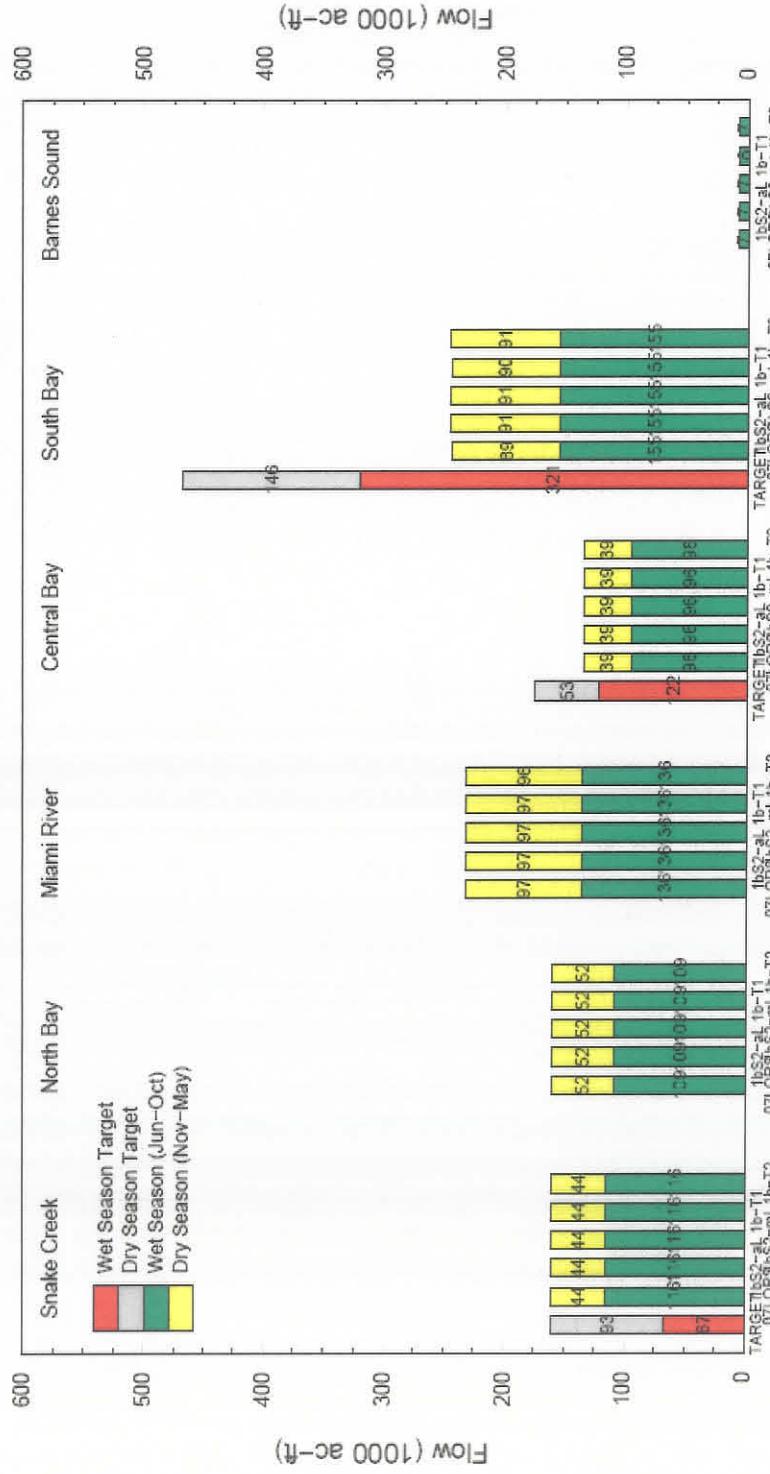


FIGURE C-32: BISCAYNE BAY, MEAN SEASONAL STRUCTURE INFLOWS (1)

Simulated Mean Seasonal Structure Flows Discharged into Biscayne Bay for 1965 – 2000



Snake Creek=S28;

North Bay=S28+S27;

Miami River=S26+S25B+S25;

Central=GS3+GS2; South=GS123+GS21A+GS20G; Barnes Sound=GS197

Targets for Central & South Bay reflect a 30% increase in mean annual dry season flows over the 2000 Base
Targets for Snake Creek reflect a minimum monthly flow volume of 13,300 ac-ft multiplied
(by 5 months for wet season and by 7 months for dry season) to maintain salinity levels below 20 ppt.

RECOVER Performance Measure

For Planning Purposes Only
Run date: 11/14/06 14:13:46
SPWMW Version: V8.22
Script used: biscoyne.scr; V1.11
Filename: biscoyne_flow_bar.flq

FIGURE C-33: BISCAYNE BAY, MEAN SEASONAL STRUCTURE INFLOWS (2)

Average Annual Overland Flow across Transects 21, 22 & 23 (1965–2000)
Westward & Southward flows towards Whitewater Bay & Florida Bay

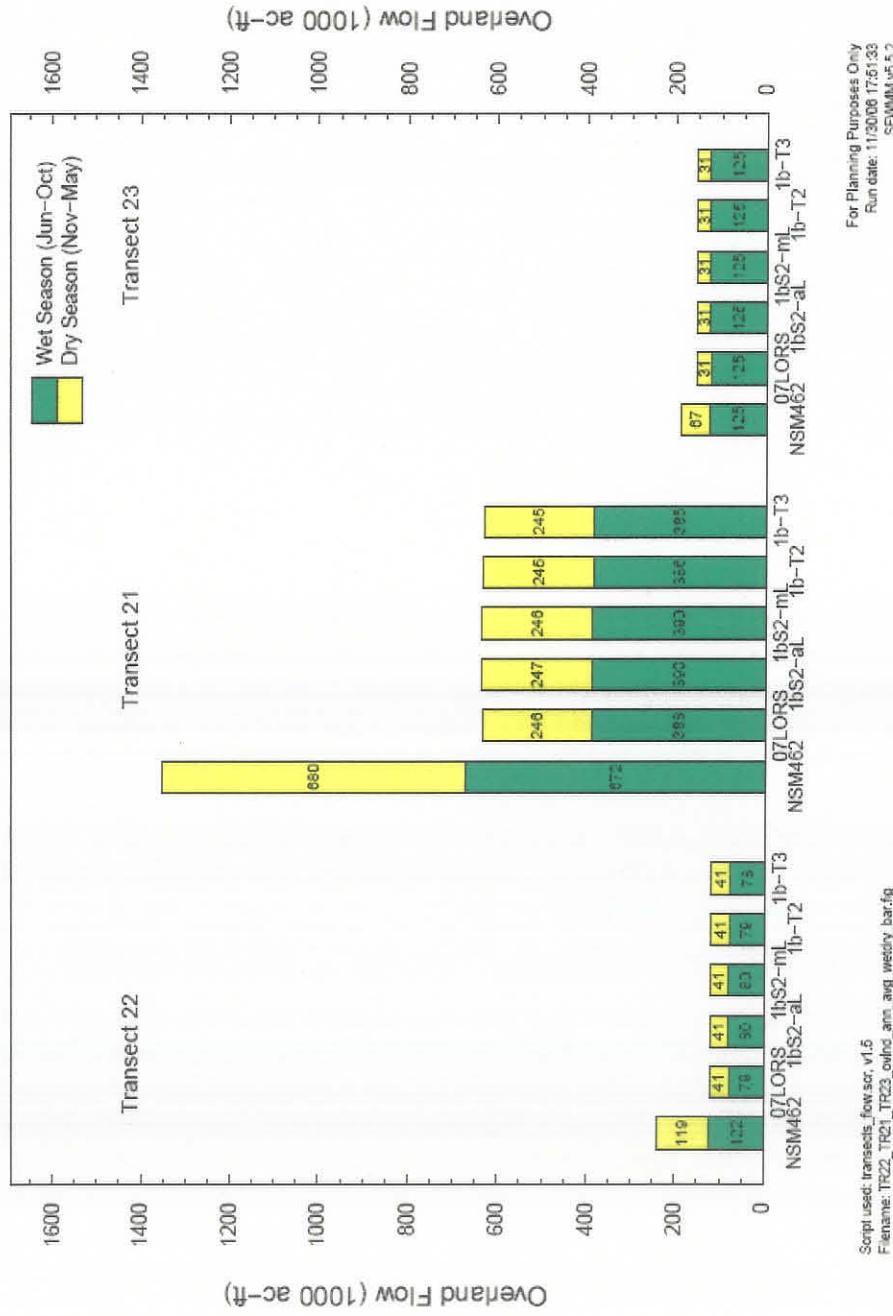


FIGURE C-34: AVERAGE ANNUAL OVERLAND FLOWS TOWARDS WHITEWATER BAY AND FLORIDA BAY (1)

Average Annual Overland Flow across Transects 21, 22 & 23 (1965-2000)
Westward & Southward flows towards Whitewater Bay & Florida Bay

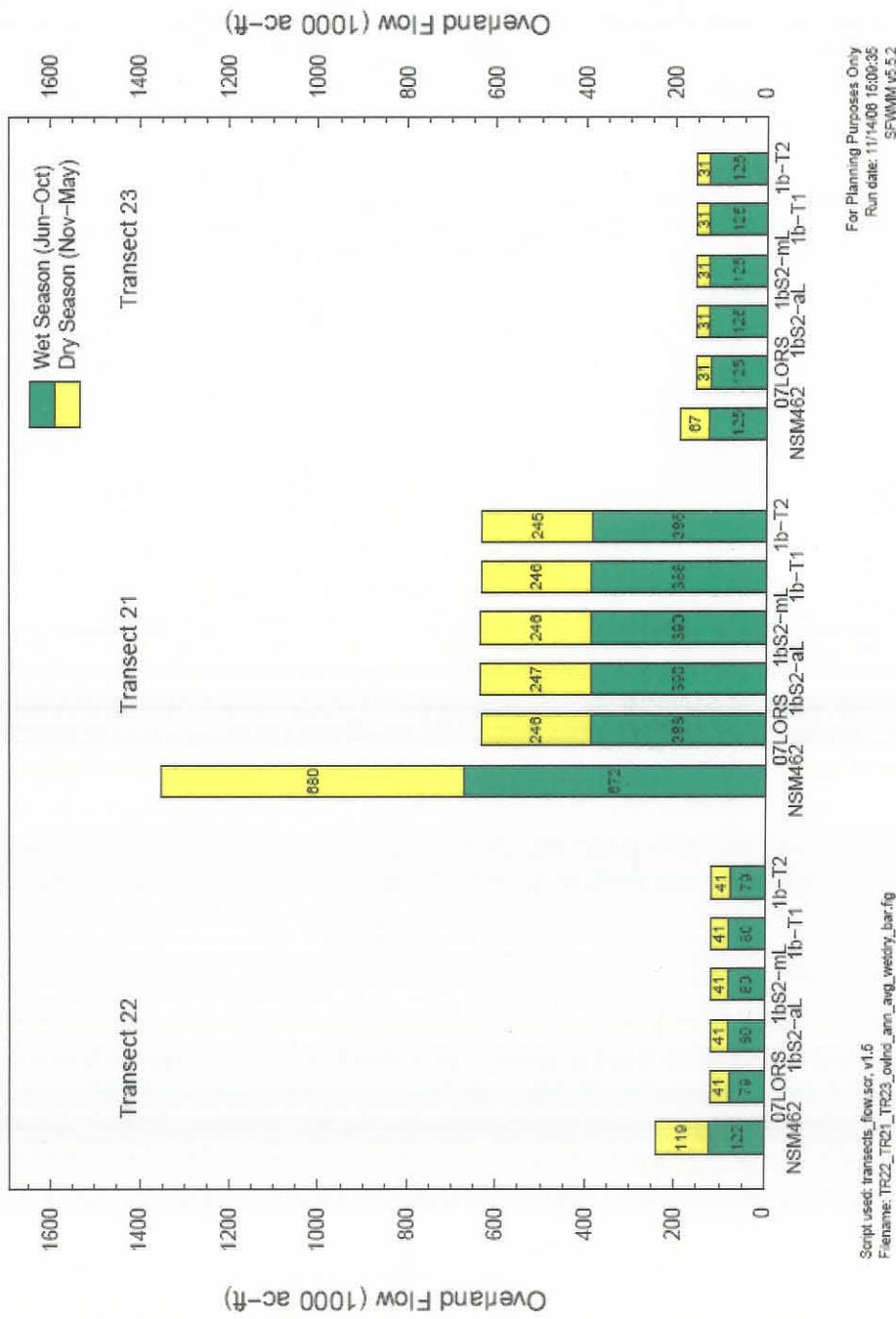


FIGURE C-35: AVERAGE ANNUAL OVERLAND FLOWS TOWARDS WHITEWATER BAY AND FLORIDA BAY (2)

Average Annual Overland Flow across Transect 1 (1965–2000)
Southward flow in WCA-1

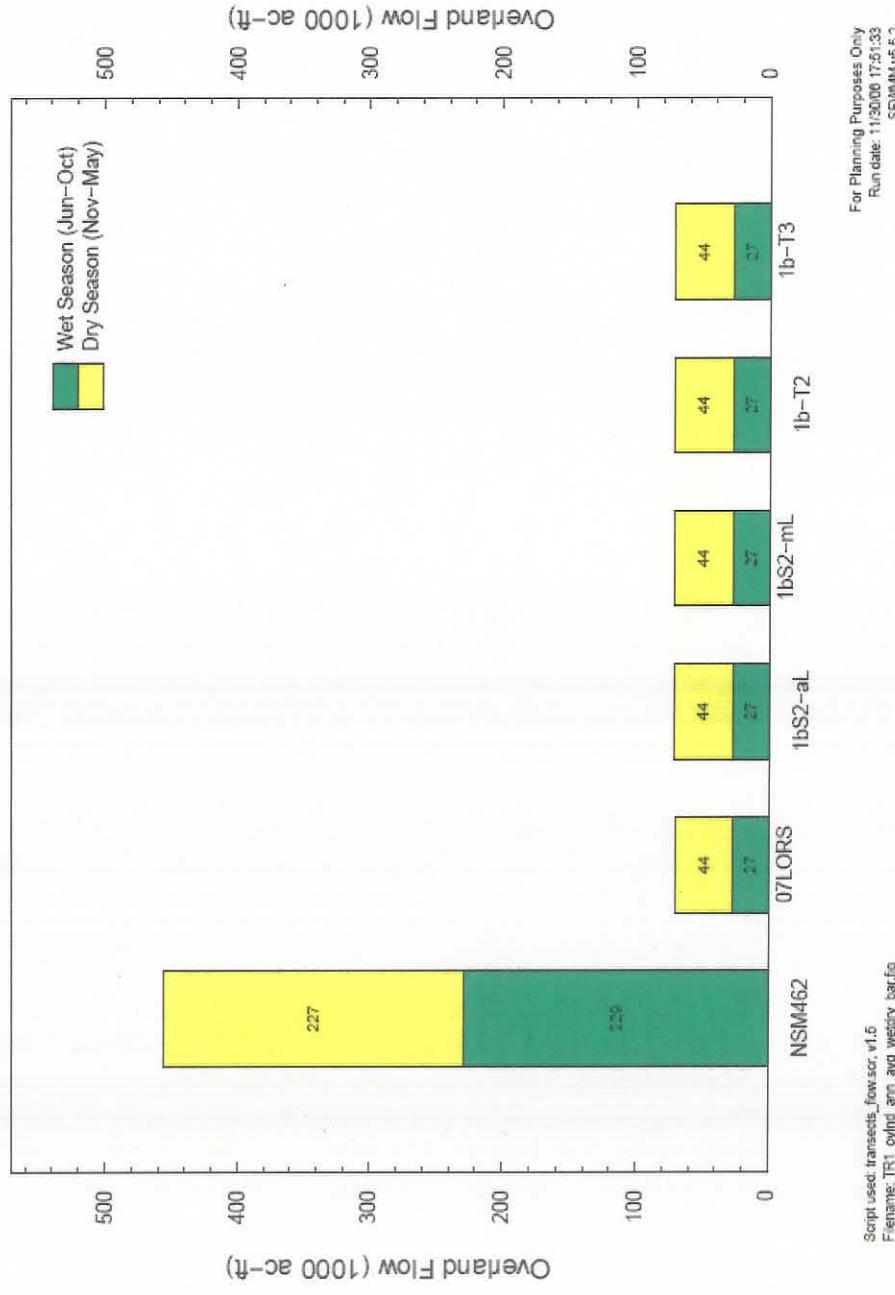


FIGURE C-36: AVERAGE ANNUAL OVERLAND FLOW ACROSS TRANSECT 1, WCA-1 (1)

Average Annual Overland Flow across Transect 1 (1965–2000)
Southward flow in WCA-1



FIGURE C-37: AVERAGE ANNUAL OVERLAND FLOW ACROSS TRANSECT 1, WCA-1 (2)

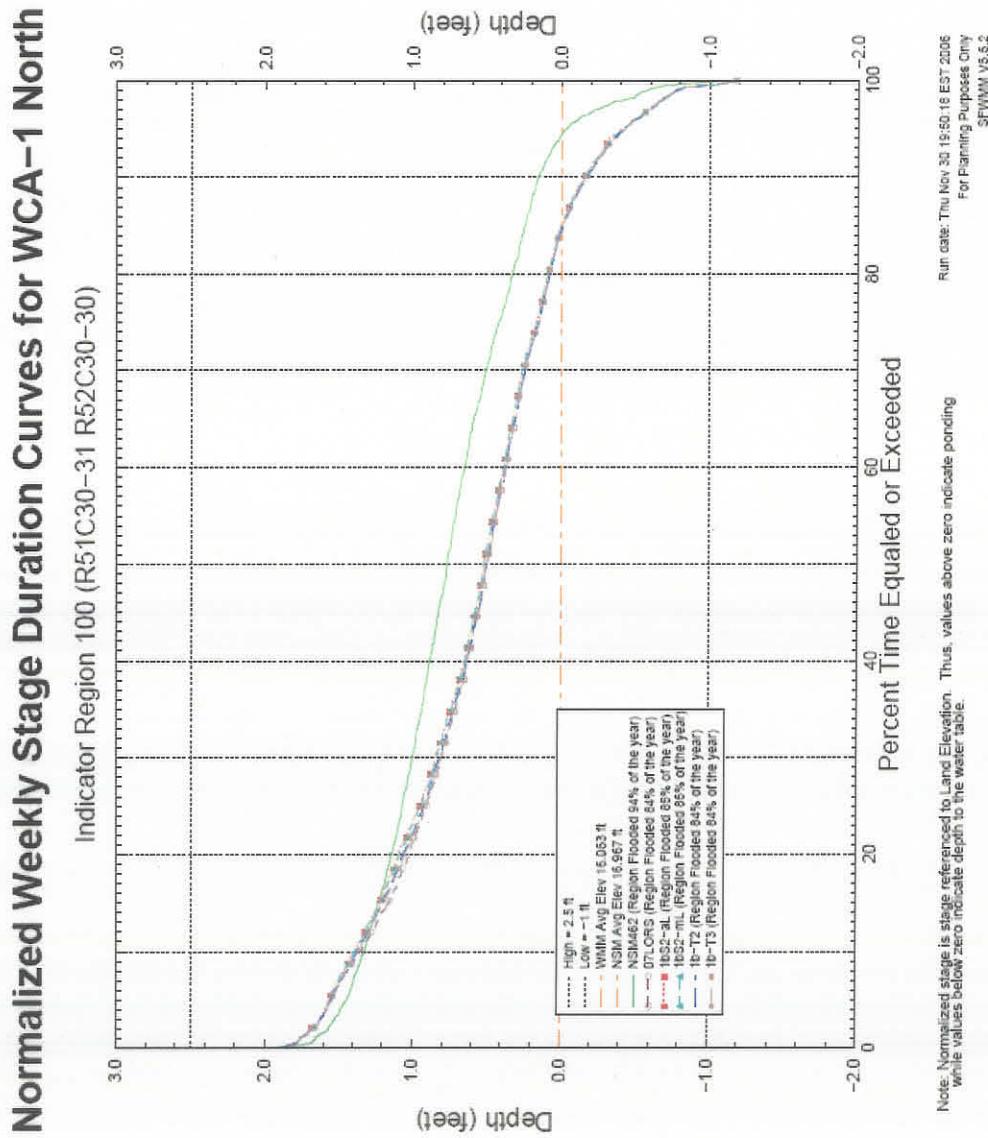
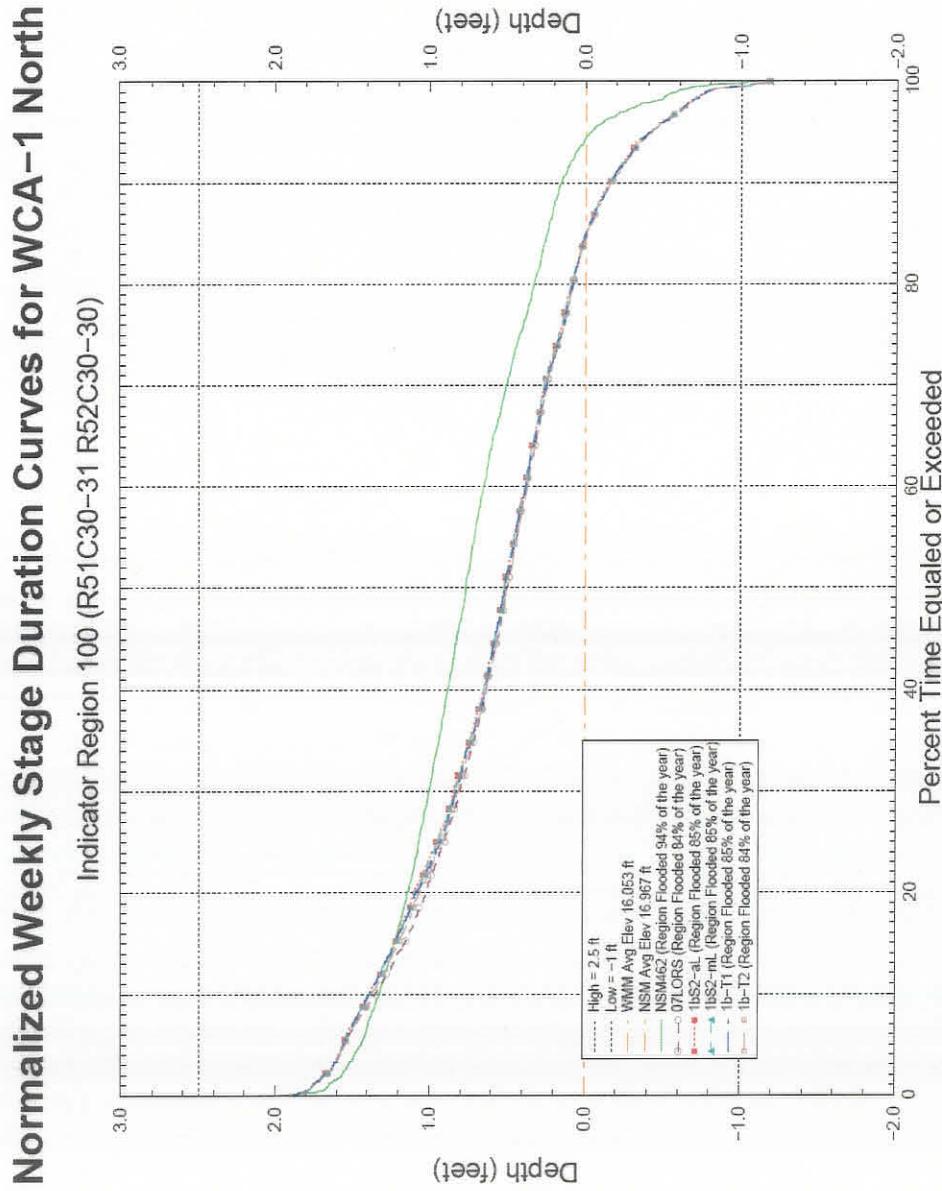


FIGURE C-38: STAGE DURATION CURVES FOR INDICATOR REGION 100, WCA-1 NORTH (1)

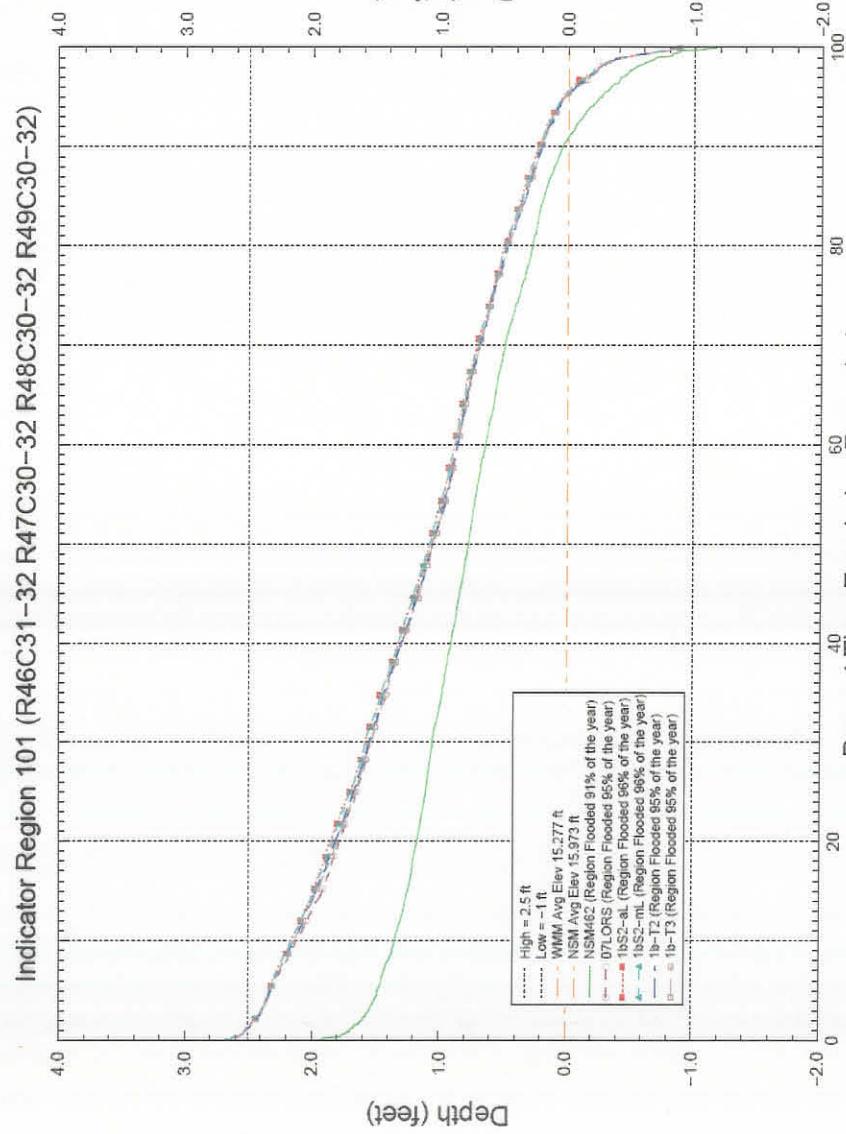


Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate flooding while values below zero indicate depth to the water table.

Run date: Tue Nov 14 16:43:24 EST 2006
For Planning Purposes Only
SFWMM V5.5.2

FIGURE C-39: STAGE DURATION CURVES FOR INDICATOR REGION 100, WCA-1 NORTH (2)

Normalized Weekly Stage Duration Curves for WCA-1 Central

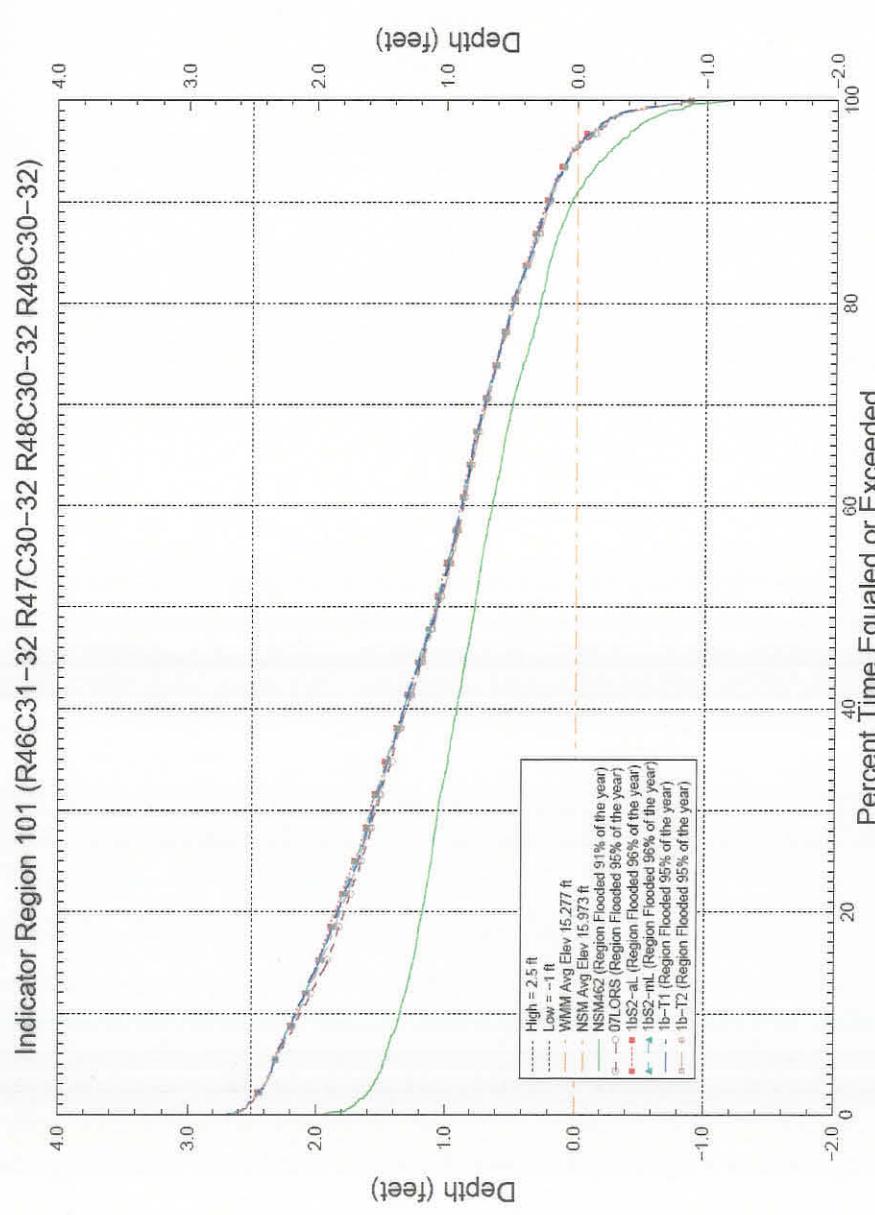


Run date: Thu Nov 30 19:50:22 EST 2006
For Planning Purposes Only
SFWMMA v5.5.2

Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

FIGURE C-40: STAGE DURATION CURVES FOR INDICATOR REGION 101, WCA-1 CENTRAL (1)

Normalized Weekly Stage Duration Curves for WCA-1 Central

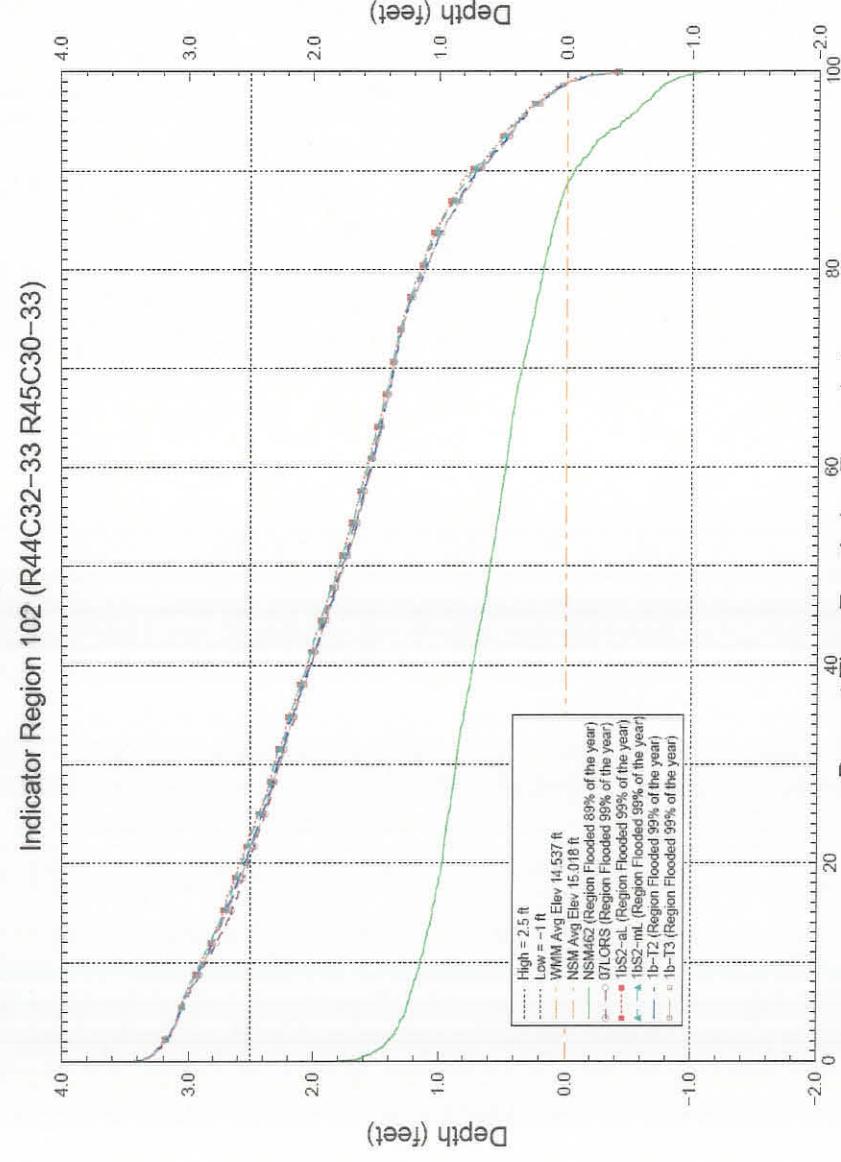


Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate pending while values below zero indicate depth to the water table.

Run date: Tue Nov 14 16:43:28 EST 2006
 For Planning Purposes Only
 SWMM V5.2

FIGURE C-41: STAGE DURATION CURVES FOR INDICATOR REGION 101, WCA-1 CENTRAL (2)

Normalized Weekly Stage Duration Curves for WCA-1 South



Run date: Thu Nov 30 19:50:26 EST 2006
For Planning Purposes Only
SFWMM V5.2

FIGURE C-42: STAGE DURATION CURVES FOR INDICATOR REGION 102, WCA-1 SOUTH (1)

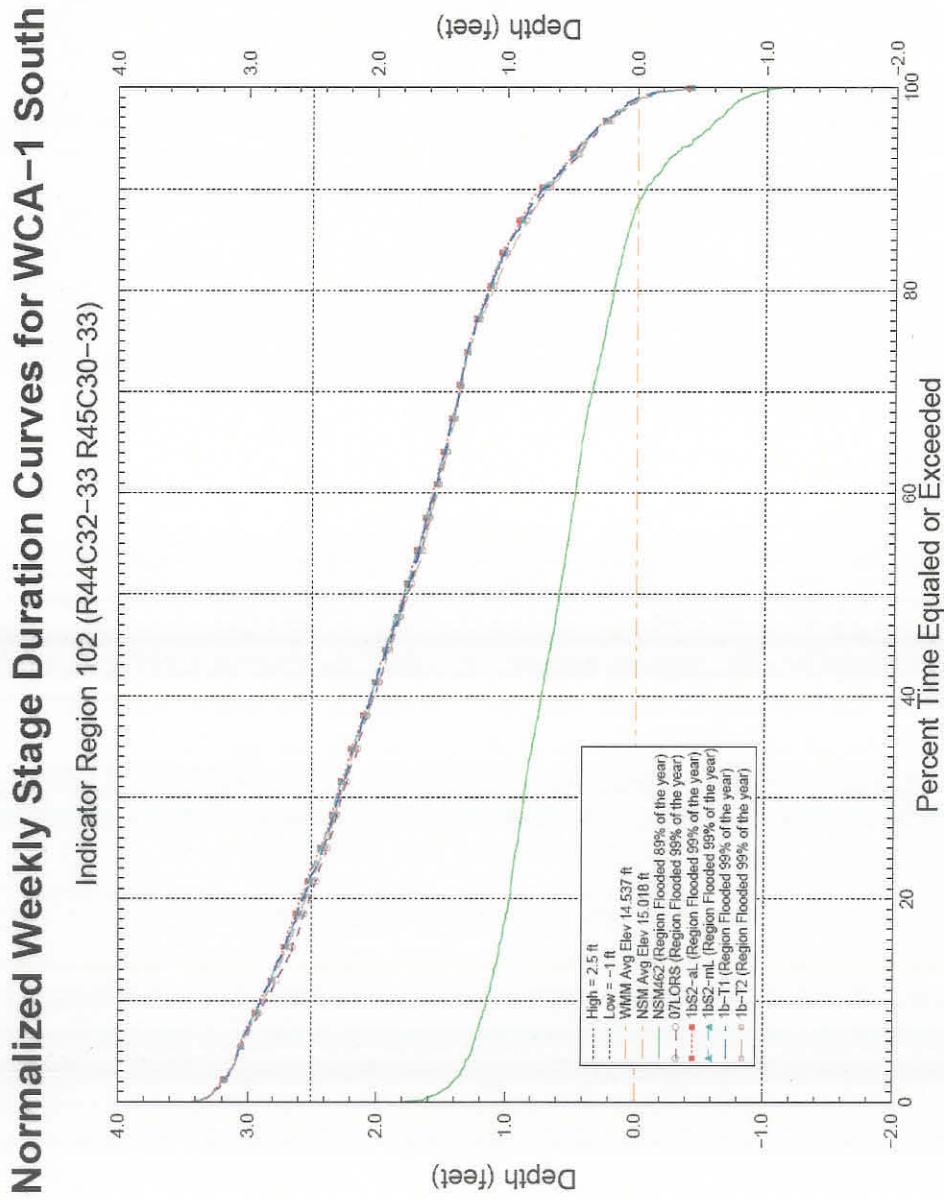
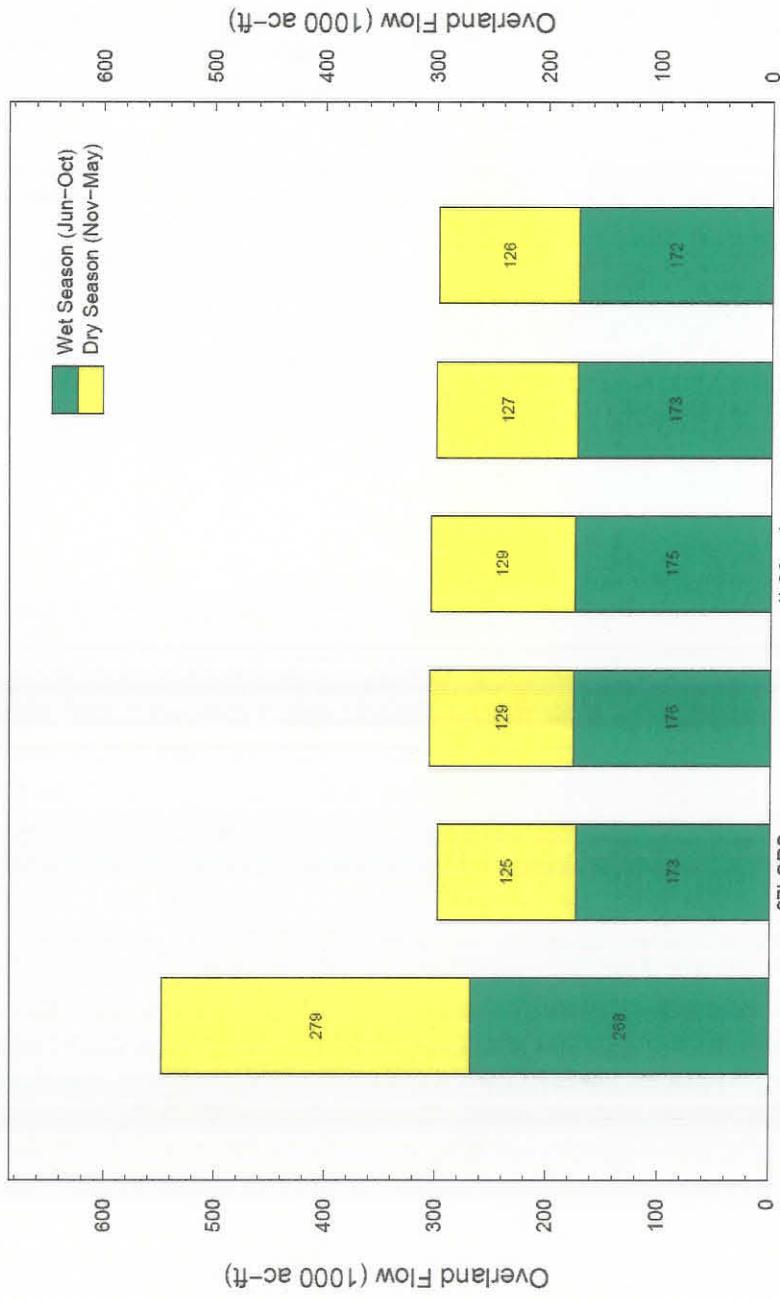


FIGURE C-43: STAGE DURATION CURVES FOR INDICATOR REGION 102, WCA-1 SOUTH (2)

Average Annual Overland Flow across Transect 2 (1965-2000)
Southward flow in WCA-2A



Script used: transects_flow.scr_v1.5
Filename: T12_ovind_am_avg_wetdry_bar.fig

For Planning Purposes Only
Run date: 1/3/2006 17:51:33
SFWMM v5.5.2

FIGURE C-44: AVERAGE ANNUAL OVERLAND FLOW ACROSS TRANSECT 2, WCA-2A (1)

Average Annual Overland Flow across Transect 2 (1965–2000)
Southward flow in WCA-2A



FIGURE C-45: AVERAGE ANNUAL OVERLAND FLOW ACROSS TRANSECT 2, WCA-2A (2)

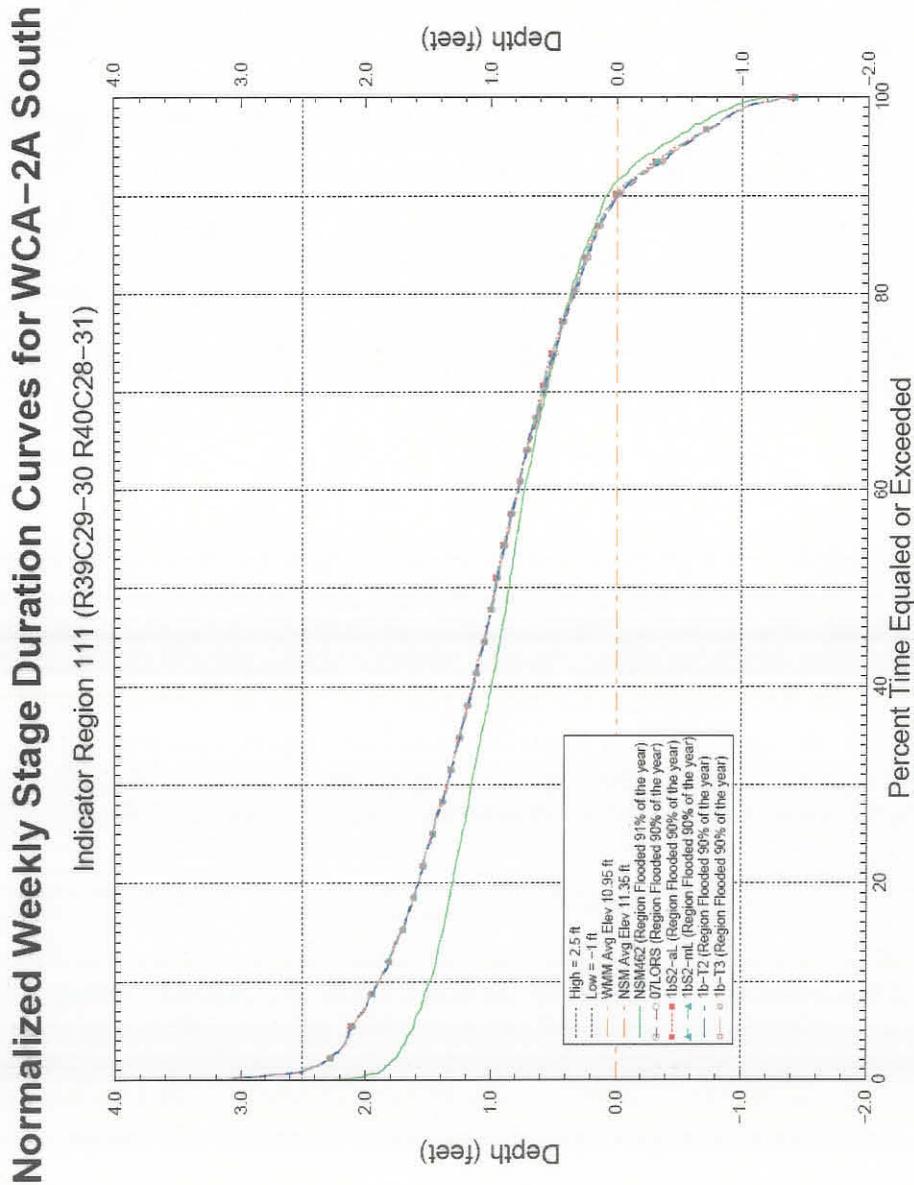
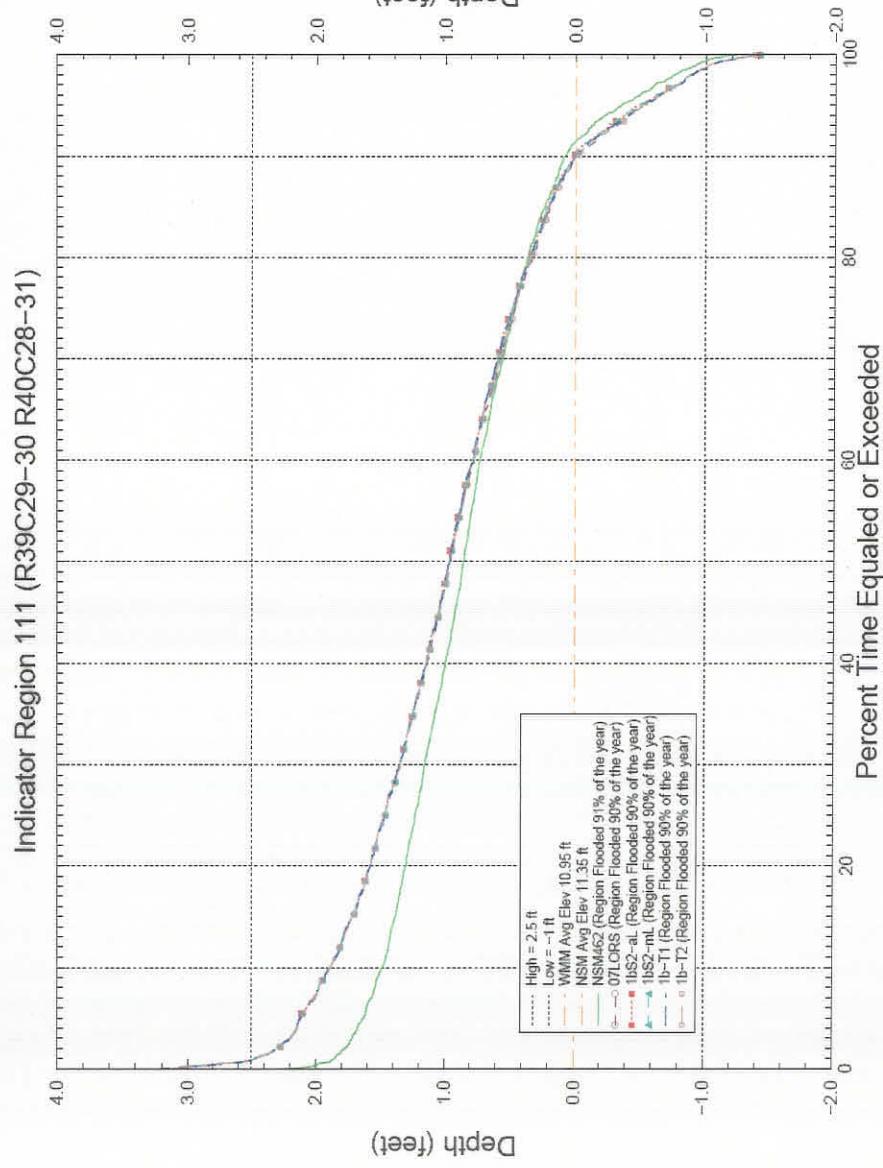


FIGURE C-46: STAGE DURATION CURVES FOR INDICATOR REGION 111, WCA-2A SOUTH (1)

Normalized Weekly Stage Duration Curves for WCA-2A South



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Tue Nov 14 16:43:37 EST 2006
For Planning Purposes Only
SFWMM V5.5.2

FIGURE C-47: STAGE DURATION CURVES FOR INDICATOR REGION 111, WCA-2A SOUTH (2)

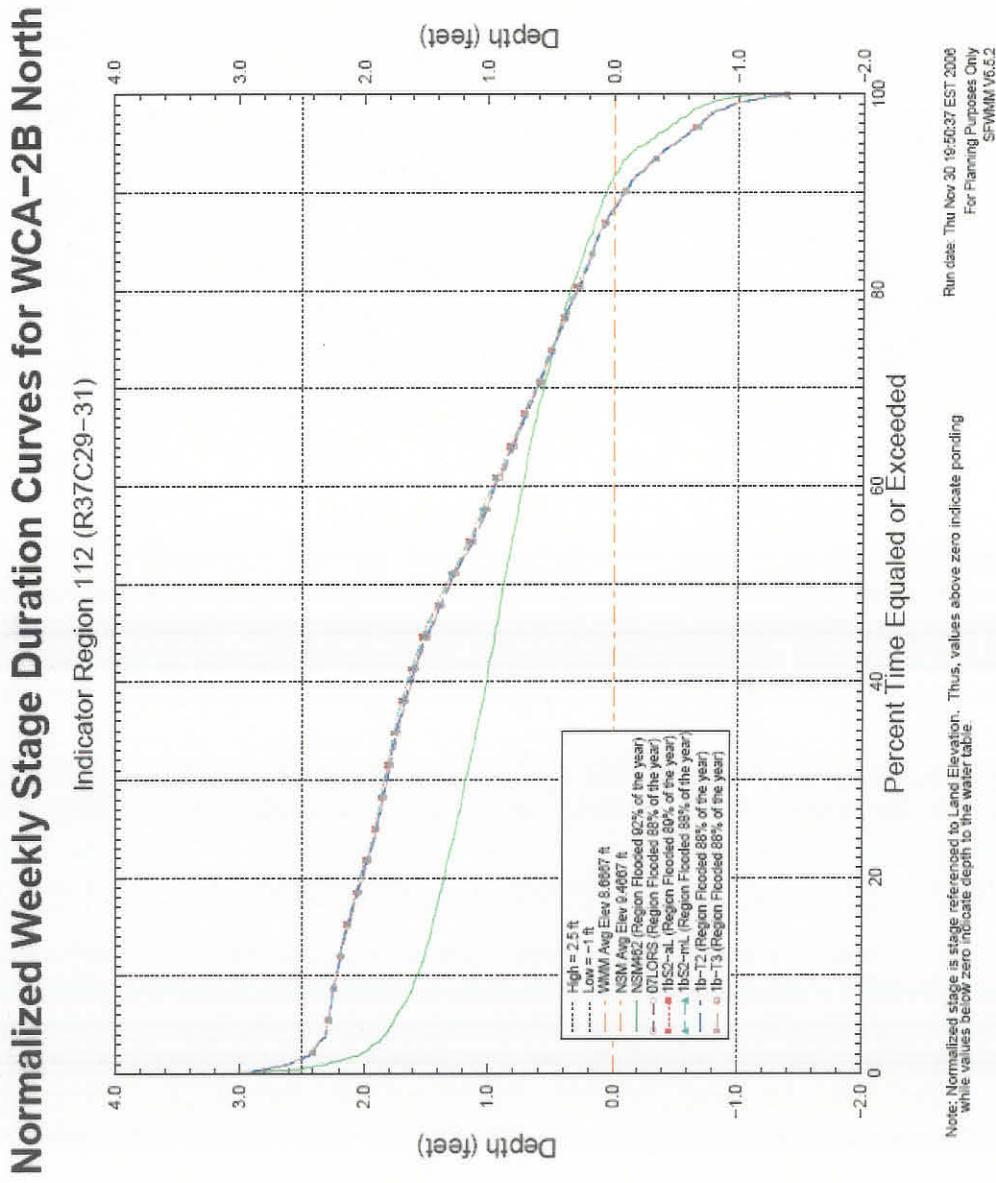


FIGURE C-48: STAGE DURATION CURVES FOR INDICATOR REGION 112, WCA-2B NORTH (1)

Normalized Weekly Stage Duration Curves for WCA-2B North

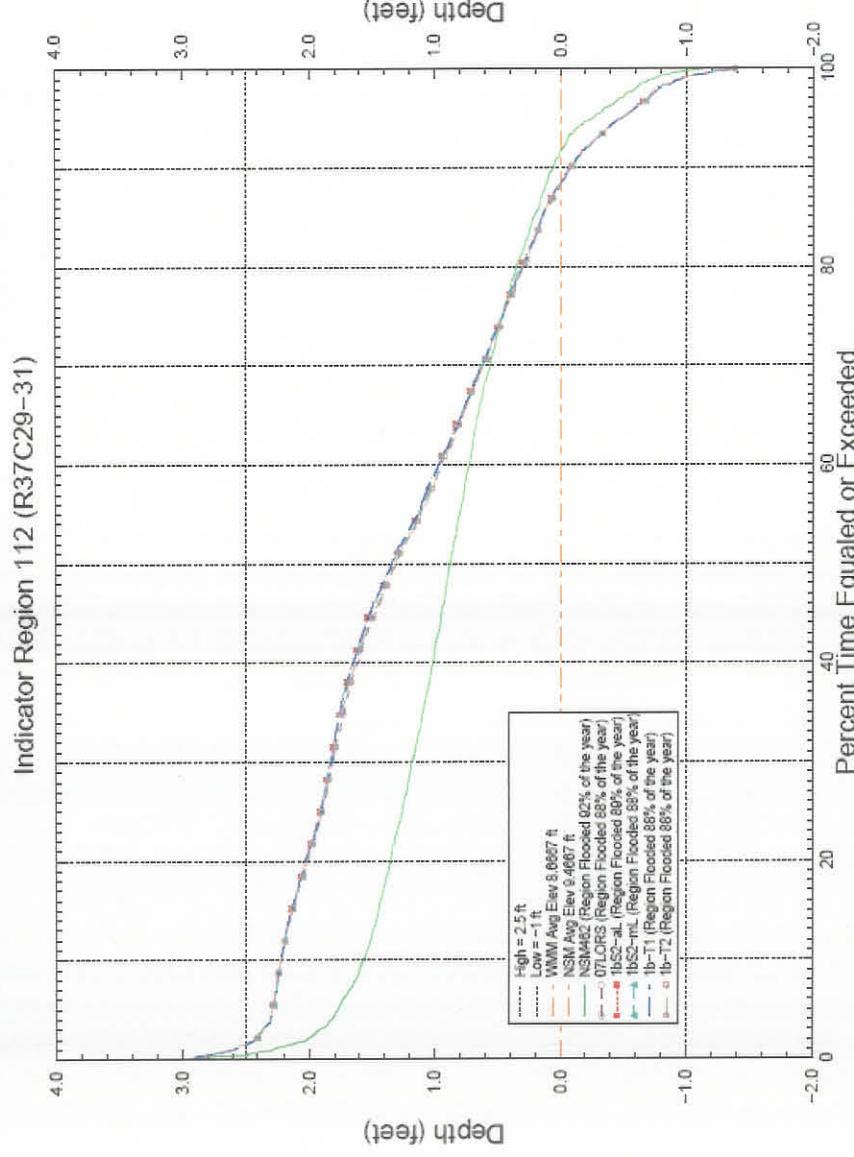
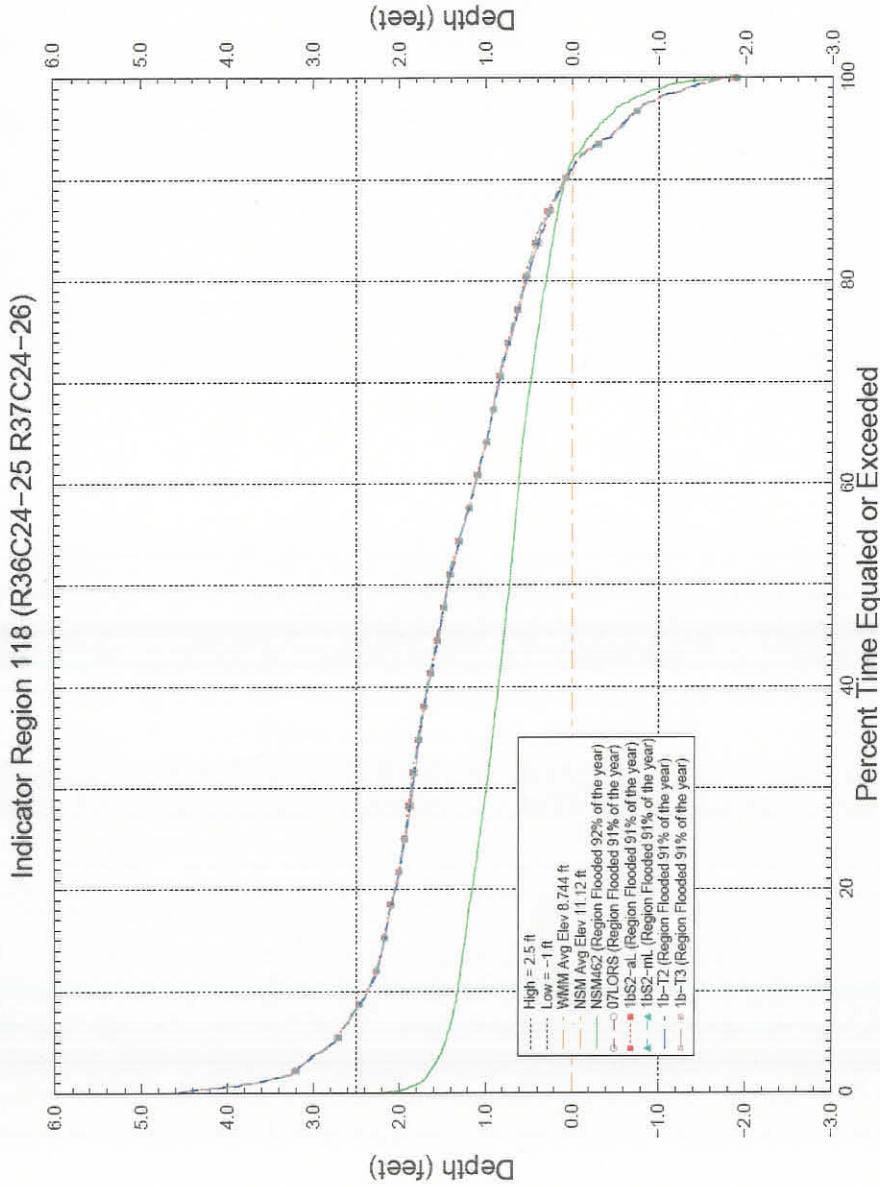


FIGURE C-49: STAGE DURATION CURVES FOR INDICATOR REGION 112, WCA-2B NORTH (2)

Normalized Weekly Stage Duration Curves for WCA-3A Alley North

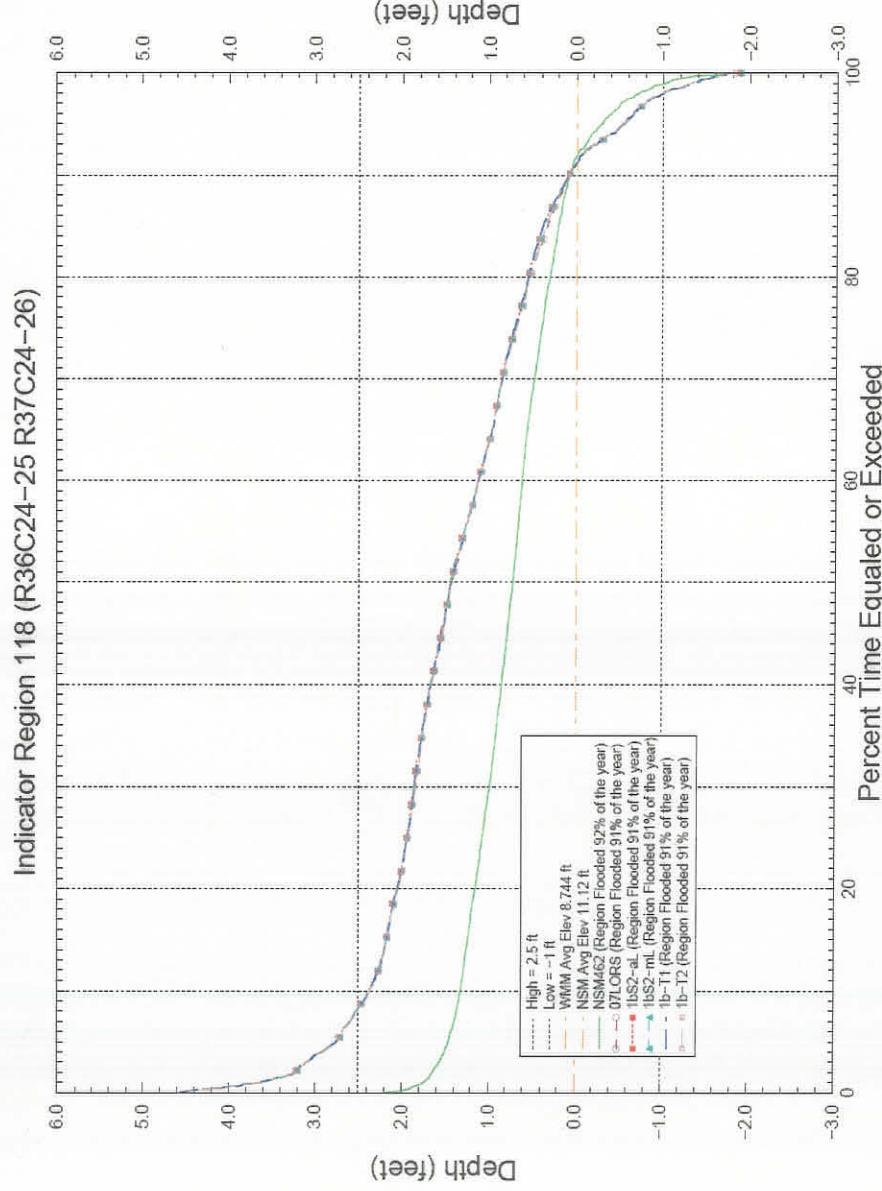


Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Thu Nov 30 19:50:57 EST 2006
For Planning Purposes Only
SFWMW V5.5.2

FIGURE C-50: STAGE DURATION CURVES FOR INDICATOR REGION 118, WCA-3A ALLEY NORTH (1)

Normalized Weekly Stage Duration Curves for WCA-3A Alley North



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate flooding while values below zero indicate depth to the water table.

Run date: Tue Nov 14 16:43:57 EST 2006
 For Planning Purposes Only
 SFWMW V5.5.2

FIGURE C-51: STAGE DURATION CURVES FOR INDICATOR REGION 118, WCA-3A ALLEY NORTH (2)

Average Annual Overland Flow across Transects 7 & 8 (1965–2000)
 Southward flows in Central WCA-3A (south of Alligator Alley – west & east of Miami Canal)

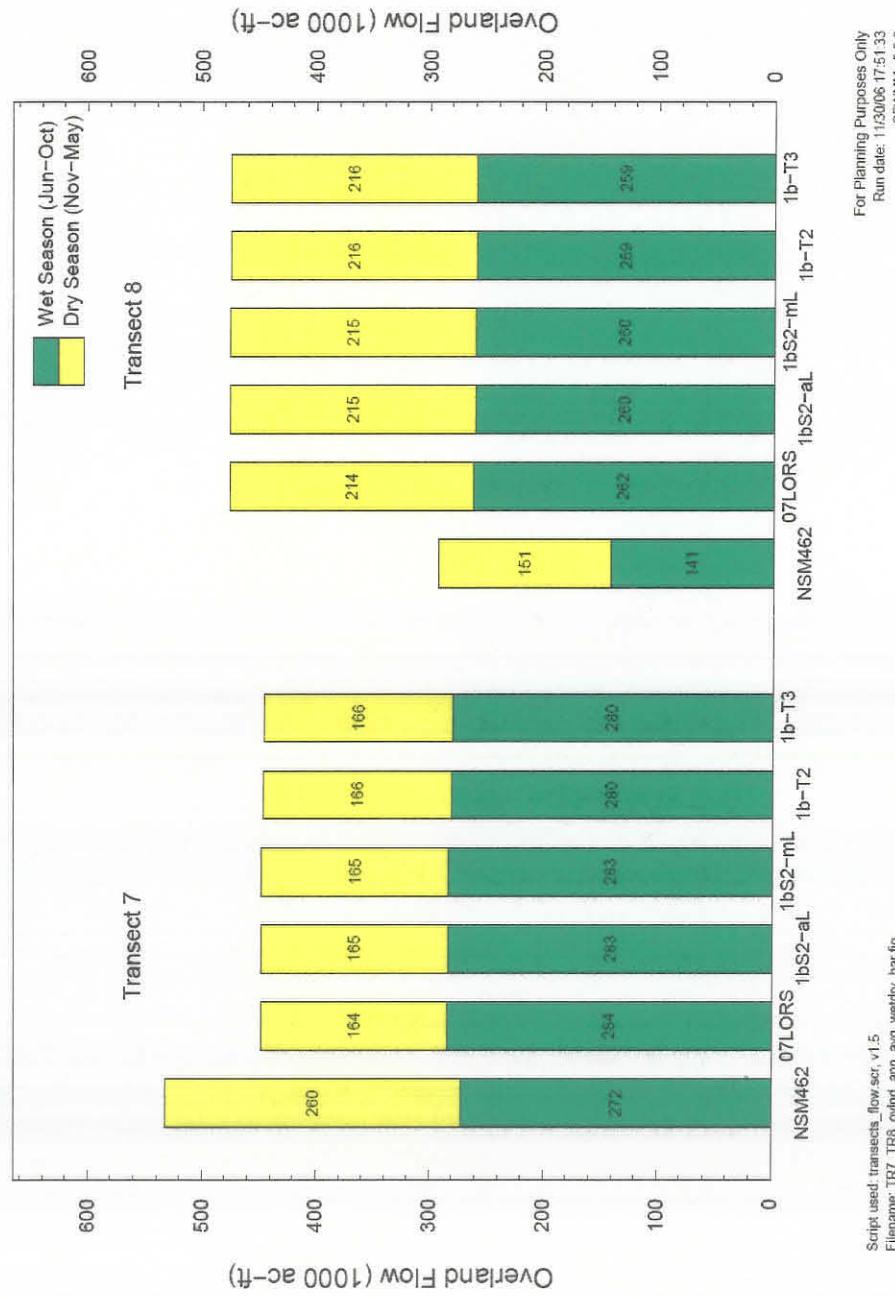


FIGURE C-52: AVERAGE ANNUAL OVERLAND FLOW ACROSS TRANSECTS 7 AND 8, CENTRAL WCA-3A (1)

Average Annual Overland Flow across Transects 7 & 8 (1965–2000)
 Southward flows in Central WCA-3A (south of Alligator Alley – west & east of Miami Canal)

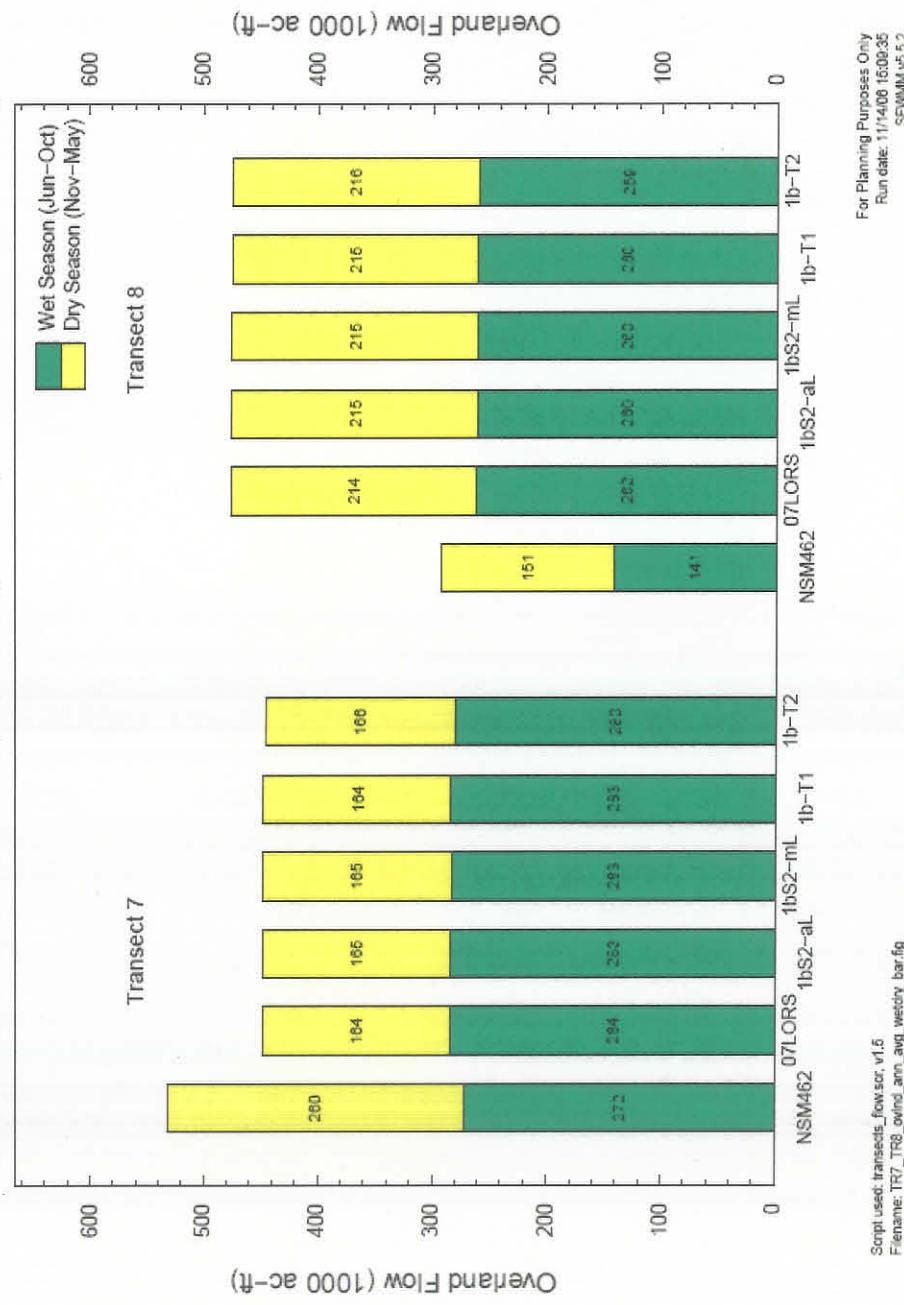
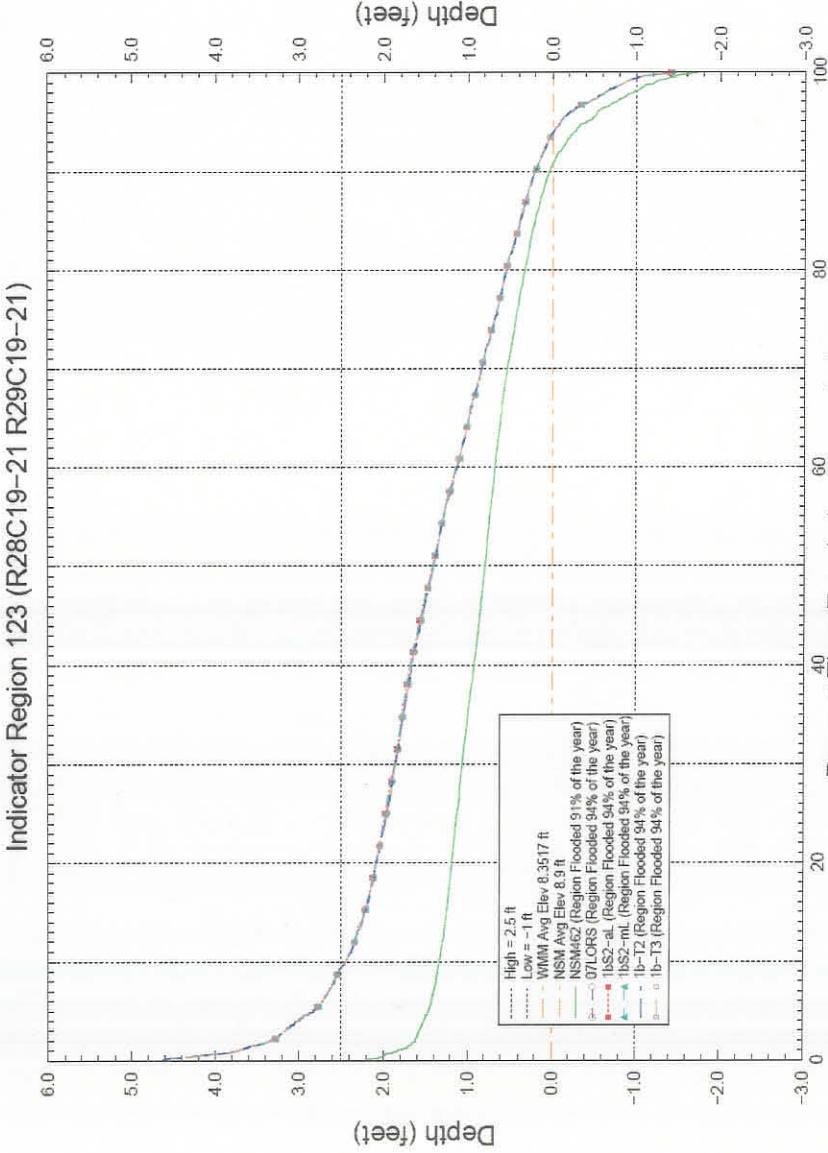


FIGURE C-53: AVERAGE ANNUAL OVERLAND FLOW ACROSS TRANSECTS 7 AND 8, CENTRAL WCA-3A (2)

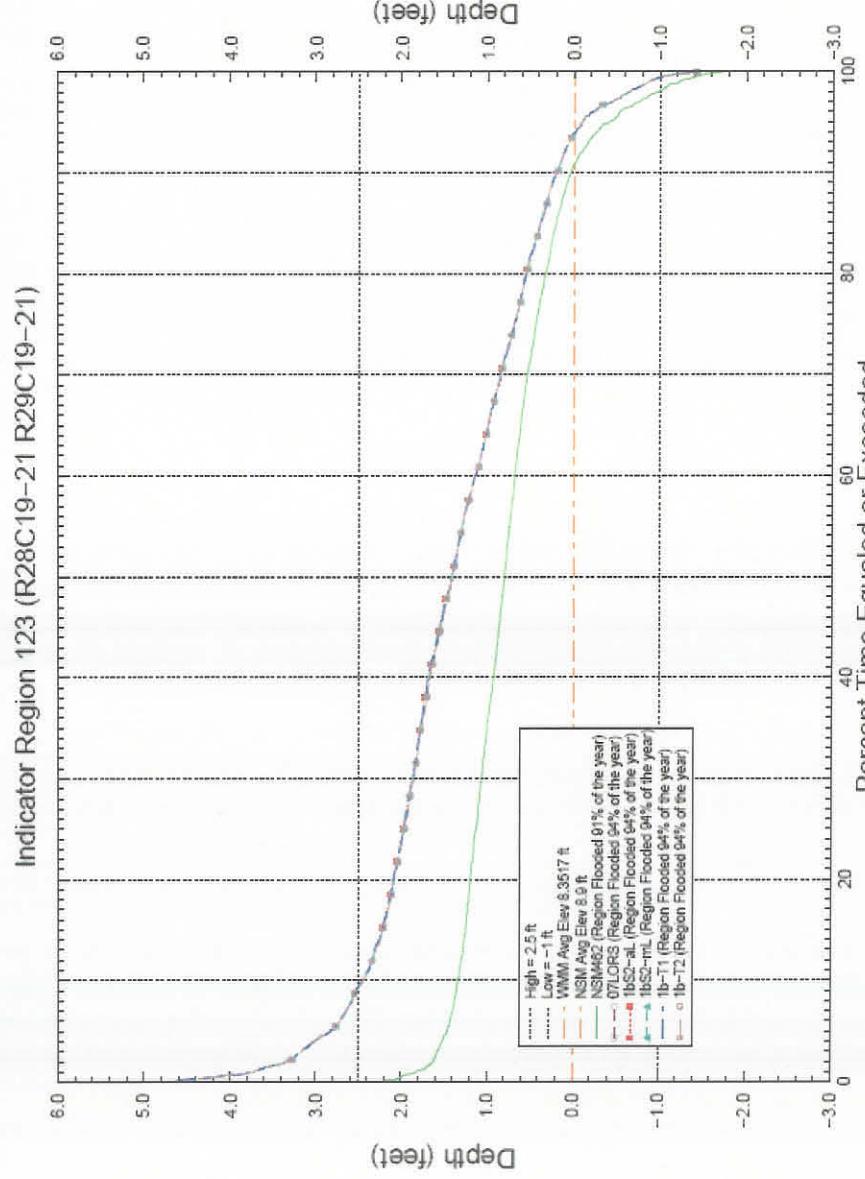
Normalized Weekly Stage Duration Curves for WCA-3A South Central



Run date: Thu Nov 30 19:51:15 EST 2006
 For Planning Purposes Only
 SFWMW V5.5.2

FIGURE C-54: STAGE DURATION CURVES FOR INDICATOR REGION 123, WCA-3A SOUTH CENTRAL (1)

Normalized Weekly Stage Duration Curves for WCA-3A South Central



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate flooding while values below zero indicate depth to the water table.

Run date: Tue Nov 14 10:44:12 EST 2008
For Planning Purposes Only
SWMM V6.5.2

FIGURE C-55: STAGE DURATION CURVES FOR INDICATOR REGION 123, WCA-3A SOUTH CENTRAL (2)

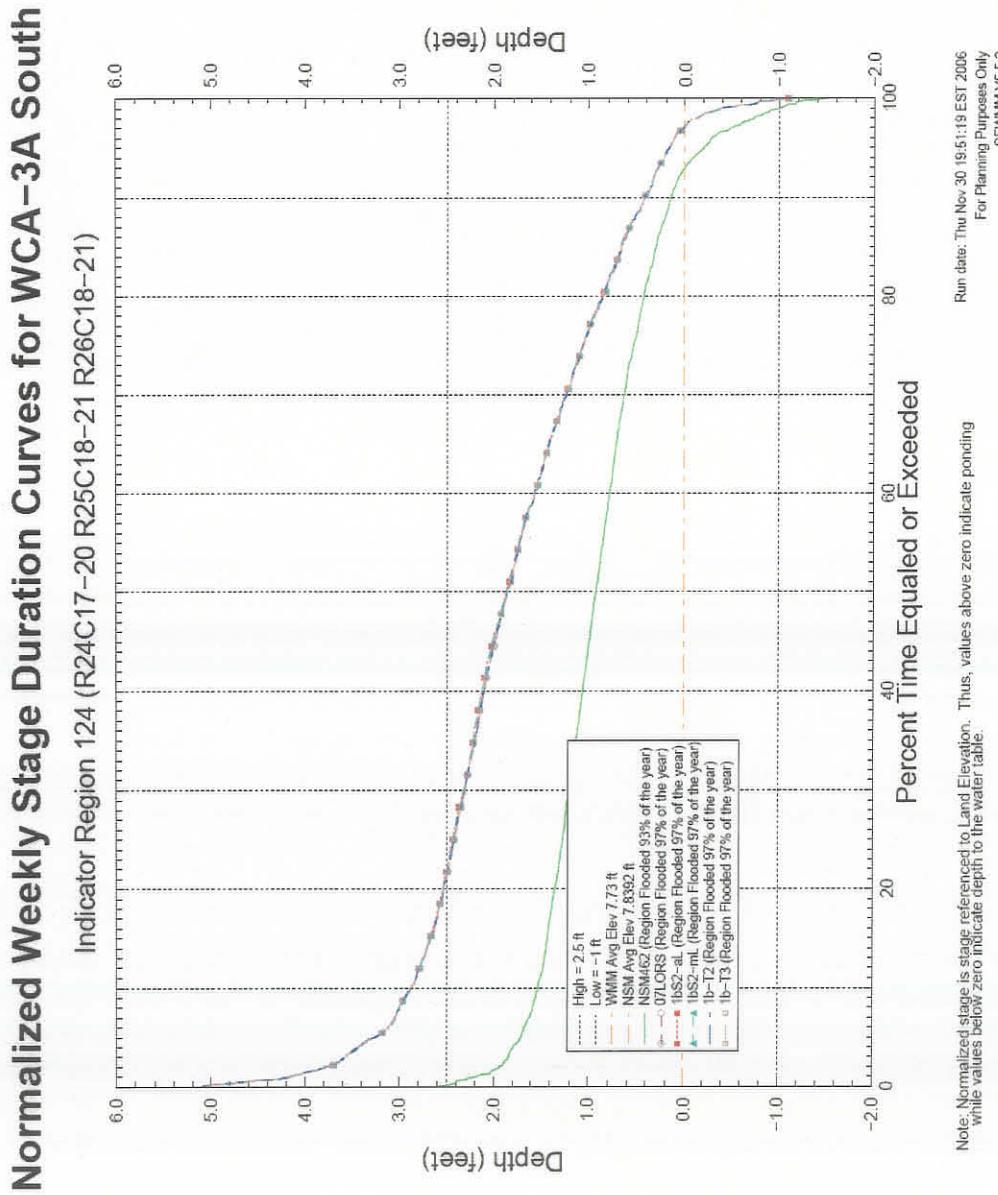
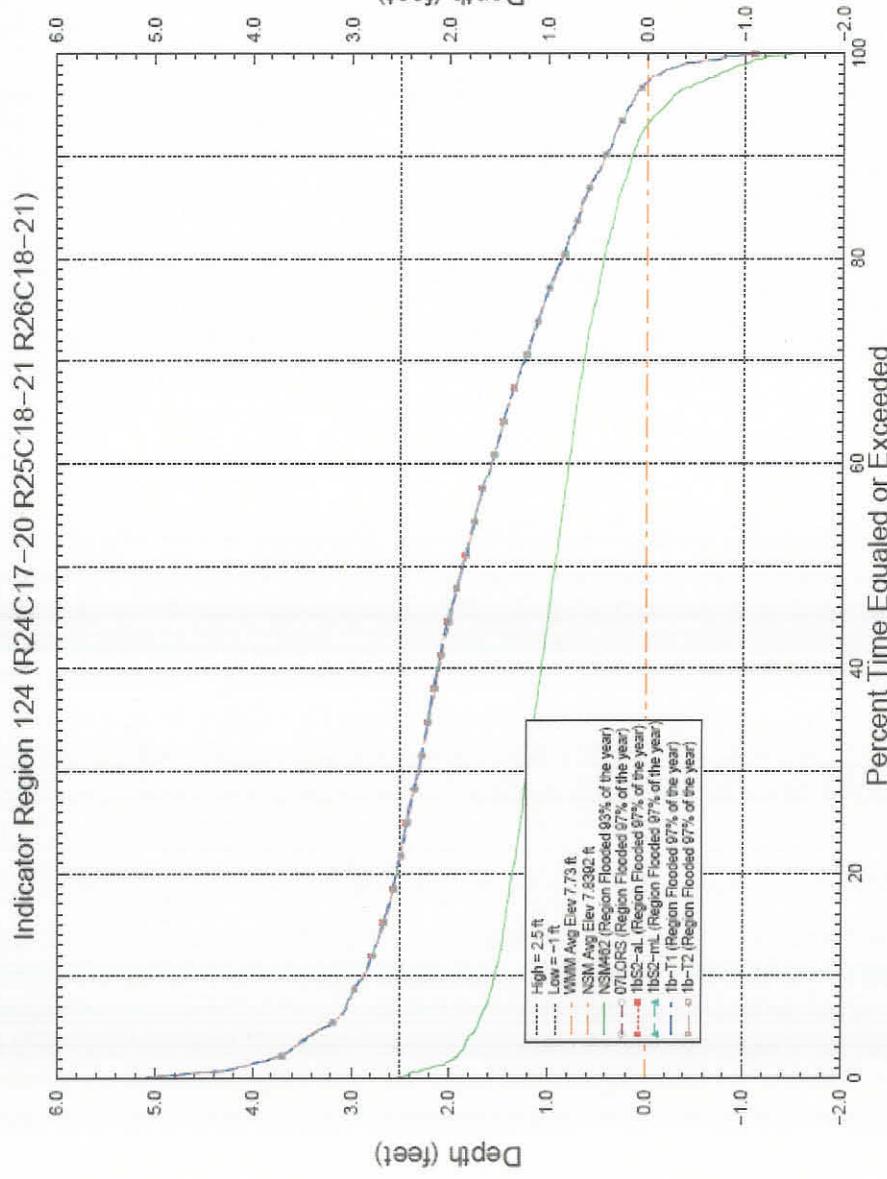


FIGURE C-56: STAGE DURATION CURVES FOR INDICATOR REGION 124, WCA-3A SOUTH (1)

Normalized Weekly Stage Duration Curves for WCA-3A South



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Tue Nov 14 16:44:16 EST 2008
For Planning Purposes Only
SF-WMM V6.6.2

FIGURE C-57: STAGE DURATION CURVES FOR INDICATOR REGION 124, WCA-3A SOUTH (2)

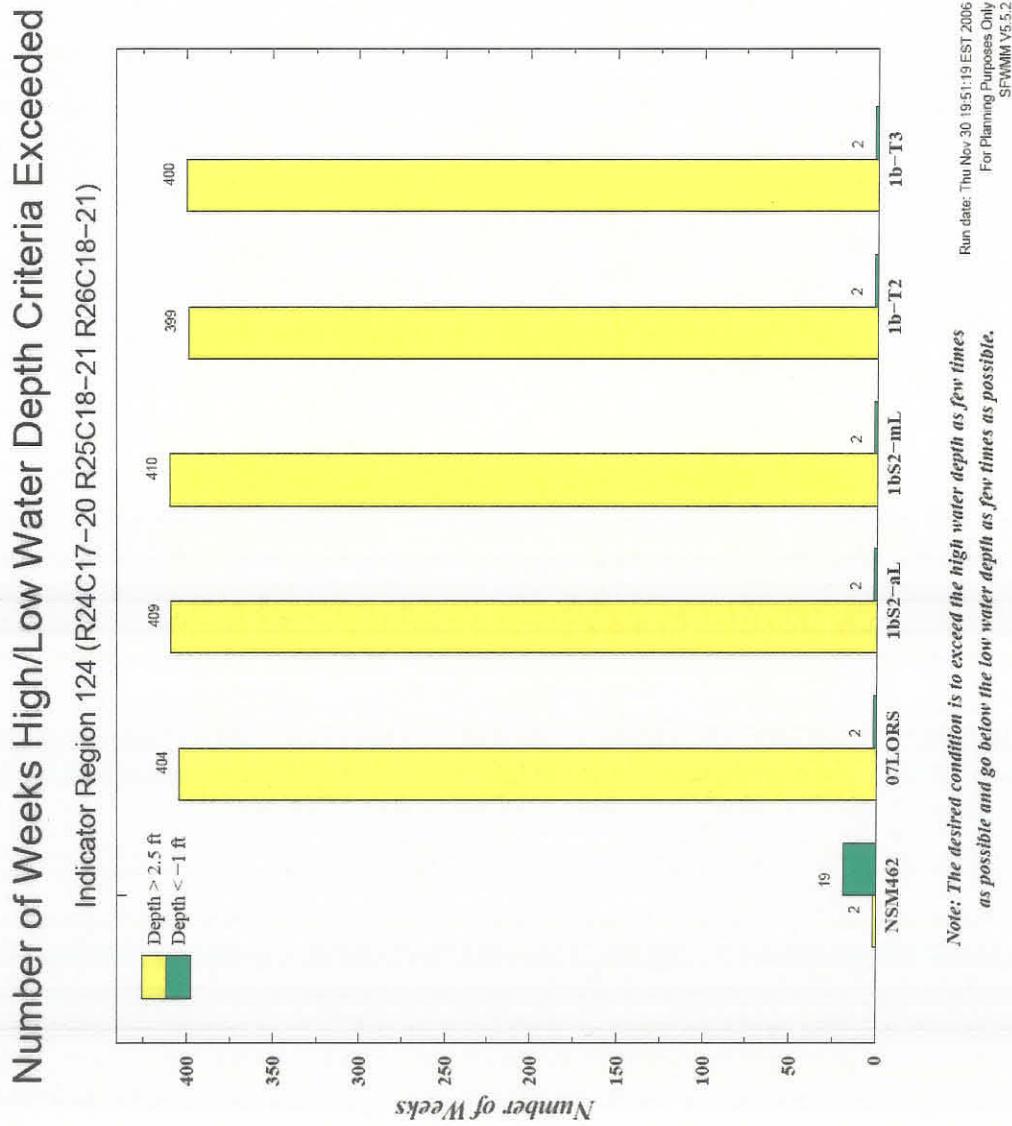
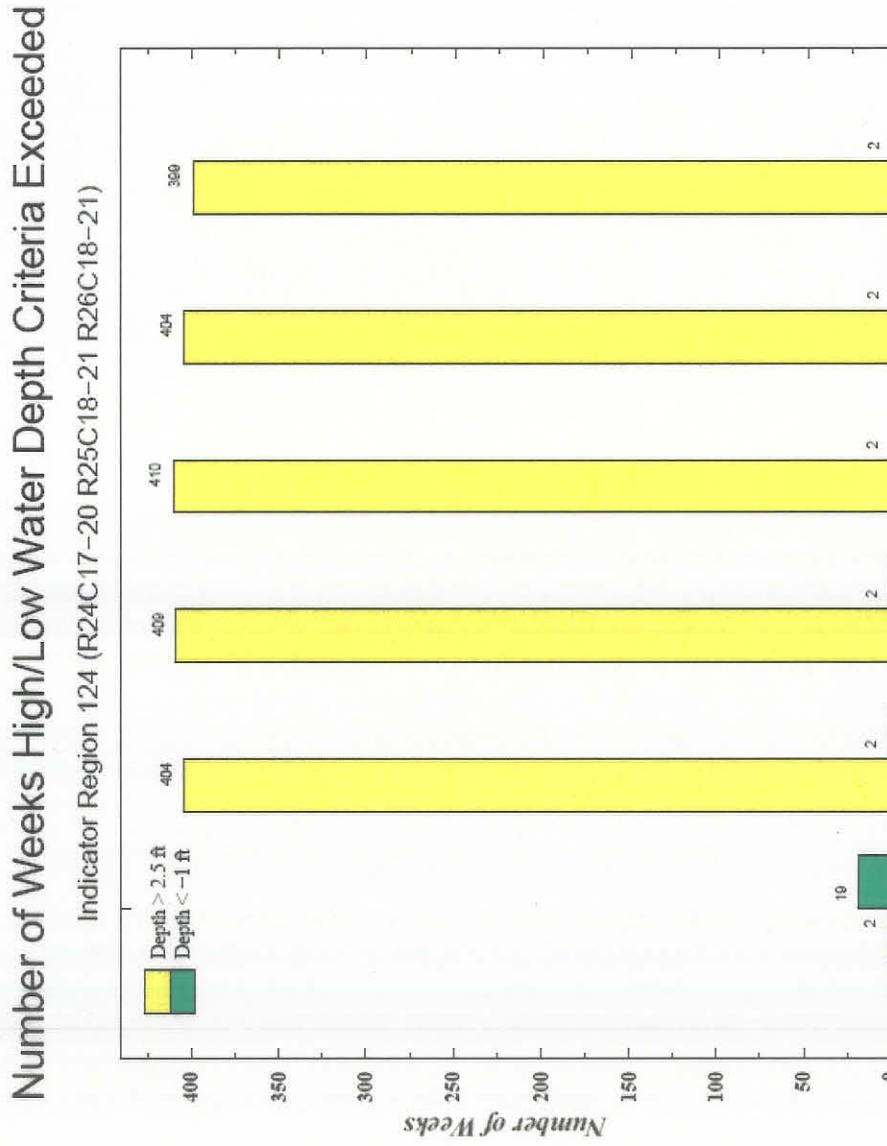


FIGURE C-58: HIGH AND LOW WATER DEPTH CRITERIA FOR INDICATOR REGION 124, WCA-3A SOUTH (1)

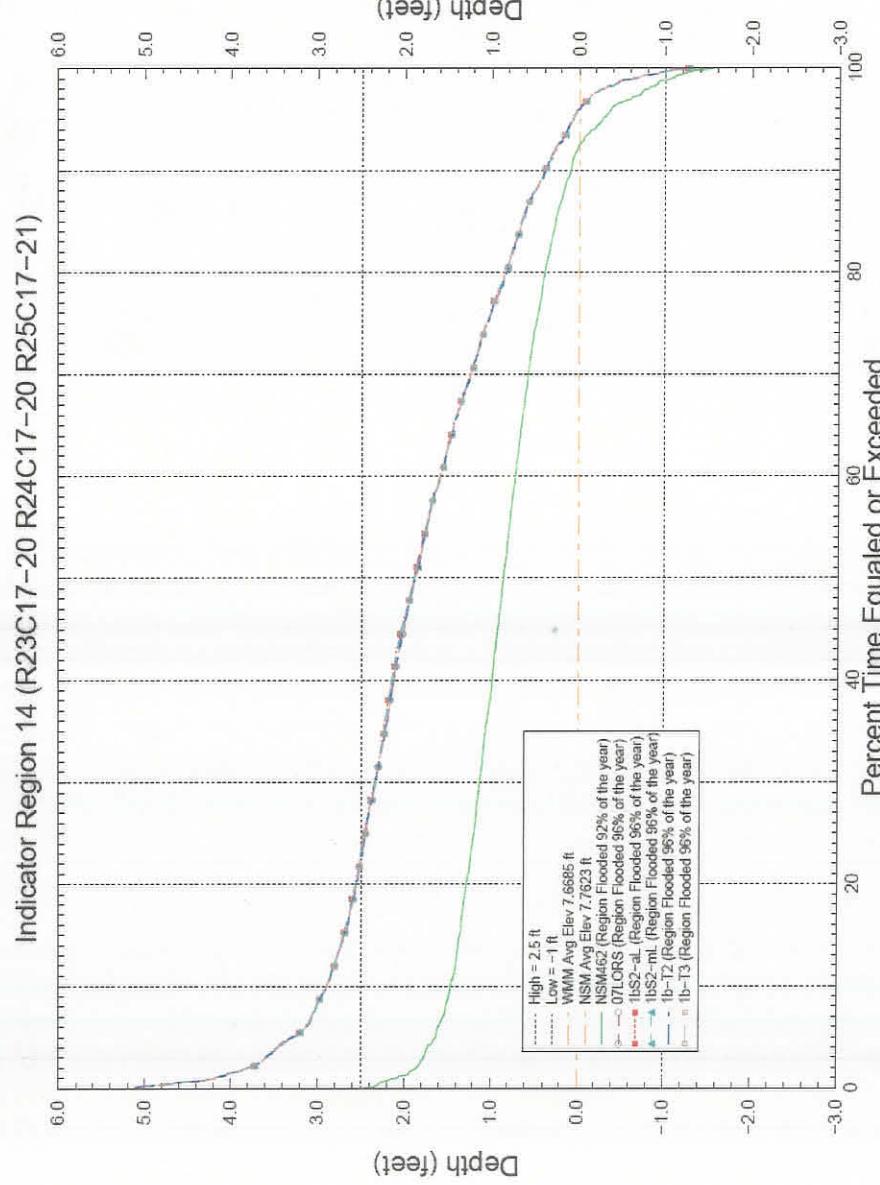


Note: The desired condition is to exceed the high water depth as few times as possible and go below the low water depth as few times as possible.

Run date: Tue Nov 14 10:44:18 EST 2006
For Planning Purposes Only
SFWMM V5.5.2

FIGURE C-59: HIGH AND LOW WATER DEPTH CRITERIA FOR INDICATOR REGION 124, WCA-3A SOUTH (2)

Normalized Weekly Stage Duration Curves for Old South WCA-3A

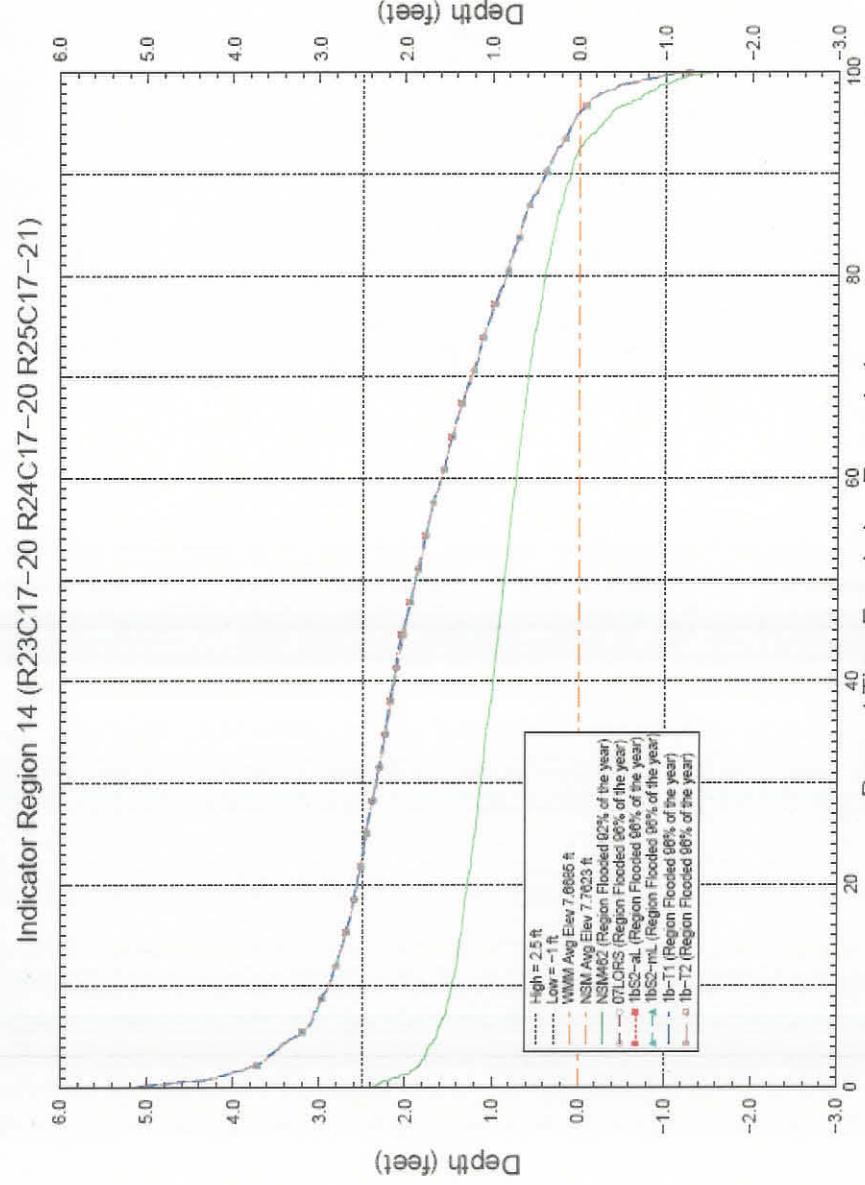


Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Thu Nov 30 19:52:59 EST 2006
For Planning Purposes Only
SFWMW V5.5.2

FIGURE C-60: STAGE DURATION CURVES FOR RESTUDY INDICATOR REGION 14, WCA-3A SOUTH (1)

Normalized Weekly Stage Duration Curves for Old South WCA-3A



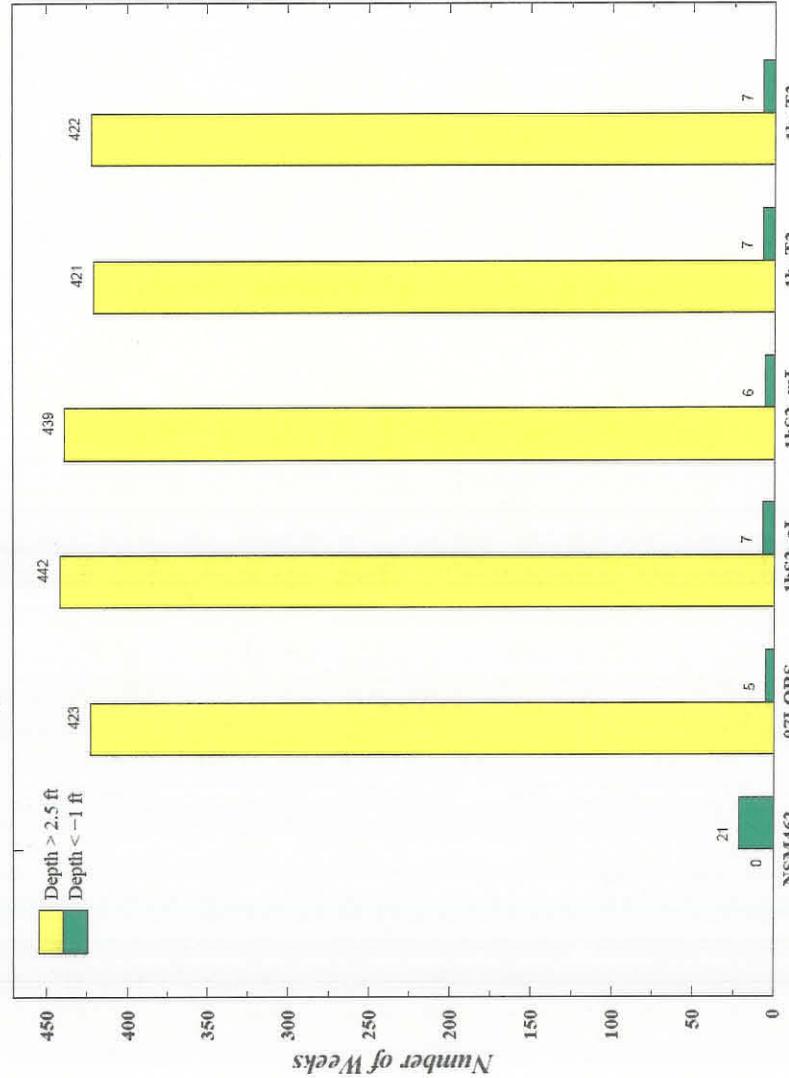
Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Tue Nov 14 10:45:46 EST 2008
For Planning Purposes Only
SWMM V6.5.2

FIGURE C-61: STAGE DURATION CURVES FOR RESTUDY INDICATOR REGION 14, WCA-3A SOUTH (2)

Number of Weeks High/Low Water Depth Criteria Exceeded

Indicator Region 14 (R23C17-20 R24C17-20 R25C17-21)



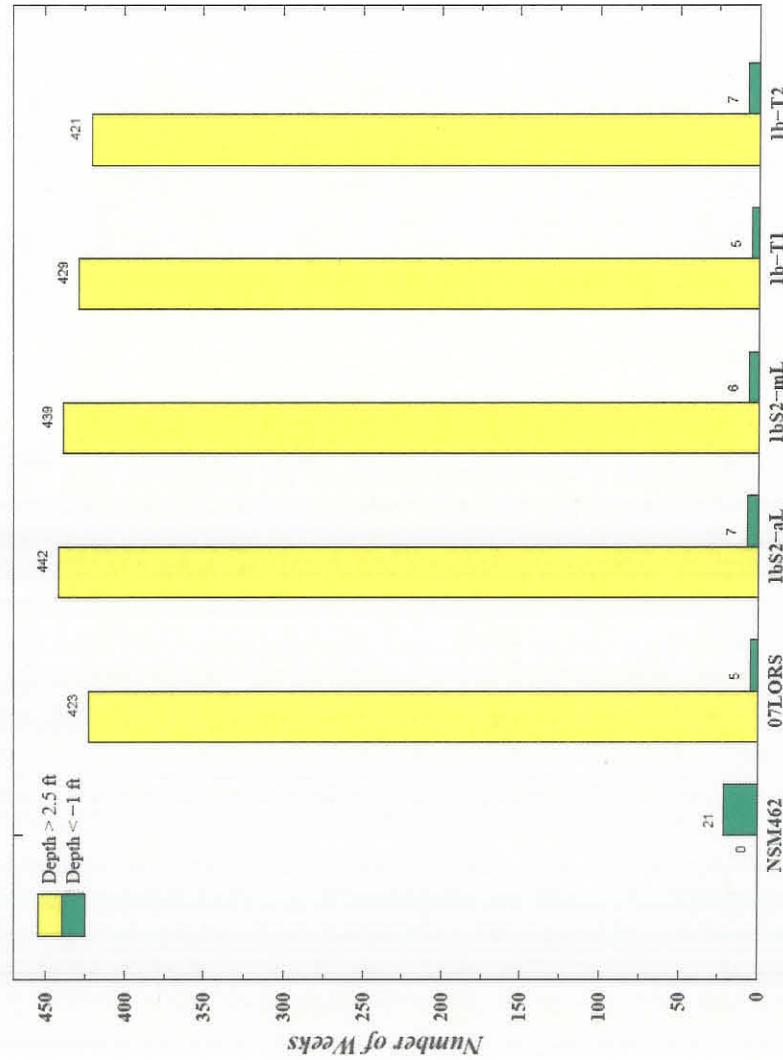
Note: The desired condition is to exceed the high water depth as few times as possible and go below the low water depth as few times as possible.

Run date: Thu Nov 30 19:52:59 EST 2006
For Planning Purposes Only
SFWMM V5.5.2

FIGURE C-62: HIGH AND LOW WATER DEPTH CRITERIA FOR RESTUDY INDICATOR REGION 14,
WCA-3A SOUTH (1)

Number of Weeks High/Low Water Depth Criteria Exceeded

Indicator Region 14 (R23C17-20 R24C17-20 R25C17-21)

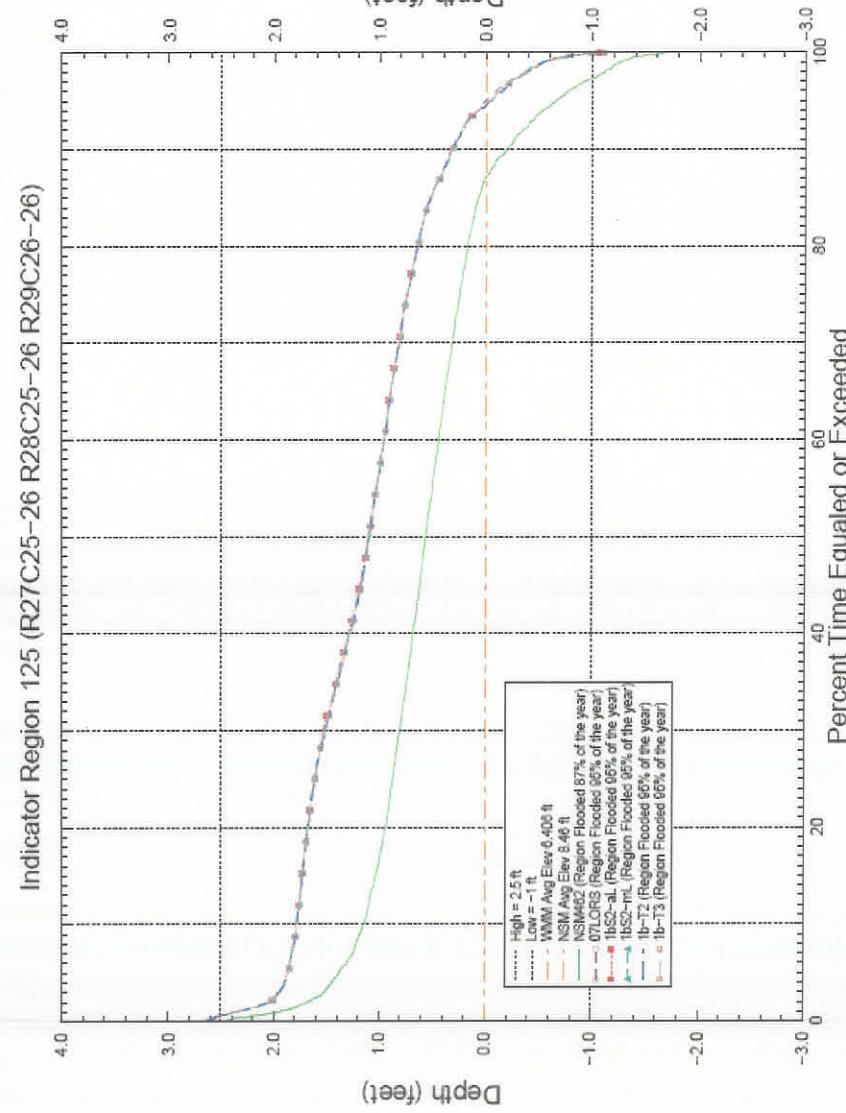


Note: The desired condition is to exceed the high water depth as few times as possible and go below the low water depth as few times as possible.

Run date: Tue Nov 14 16:45:46 EST 2006
For Planning Purposes Only
SFWMW v5.5.2

FIGURE C-63: HIGH AND LOW WATER DEPTH CRITERIA FOR RESTUDY INDICATOR REGION 14,
WCA-3A SOUTH (2)

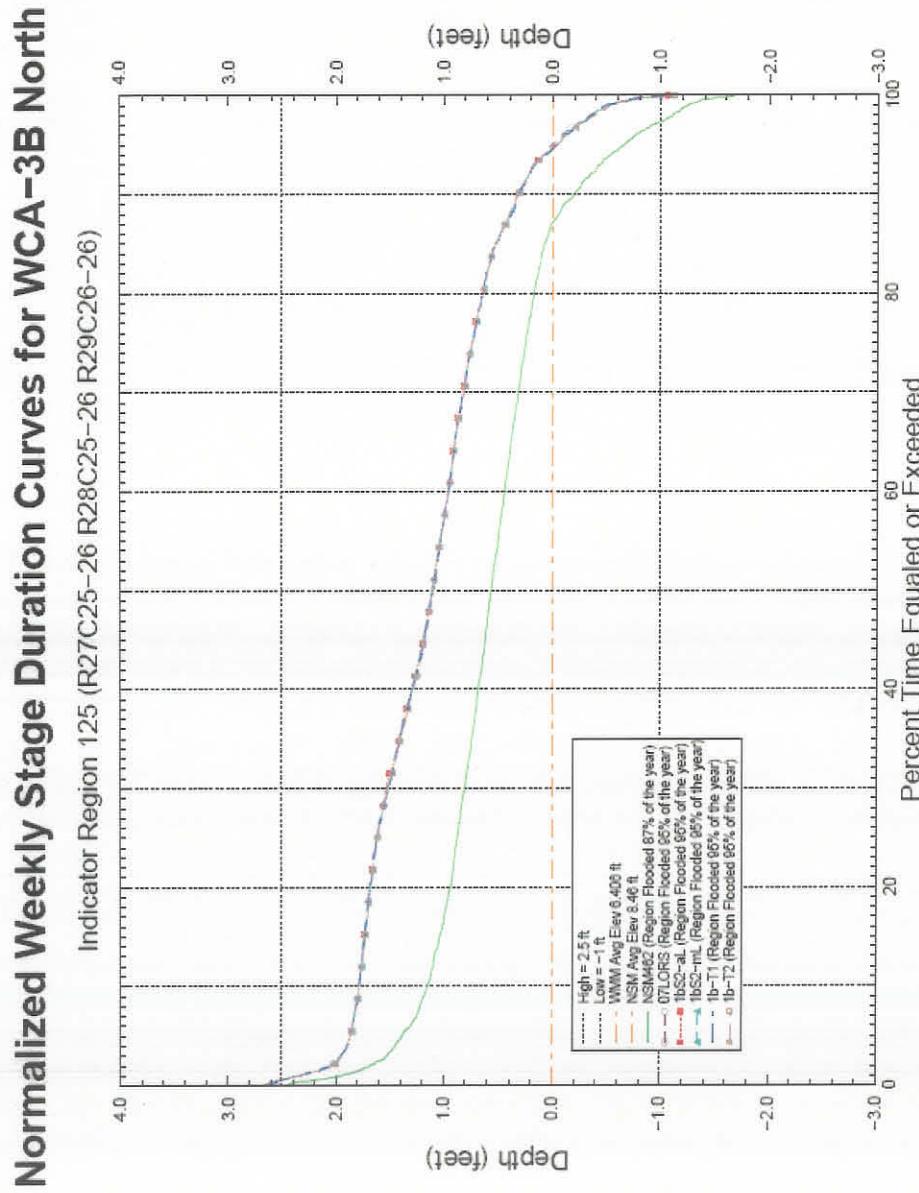
Normalized Weekly Stage Duration Curves for WCA-3B North



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding.
While values below zero indicate depth to the water value.

Run date: Thu Nov 30 10:51:22 EST 2006
For Planning Purposes Only
SFWMN v6.5.2

FIGURE C-64: STAGE DURATION CURVES FOR INDICATOR REGION 125, WCA-3B NORTH (1)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Tue Nov 14 10:44:19 EST 2006
For Planning Purposes Only
SFWMW V6.5.2

FIGURE C-65: STAGE DURATION CURVES FOR INDICATOR REGION 125, WCA-3B NORTH (2)

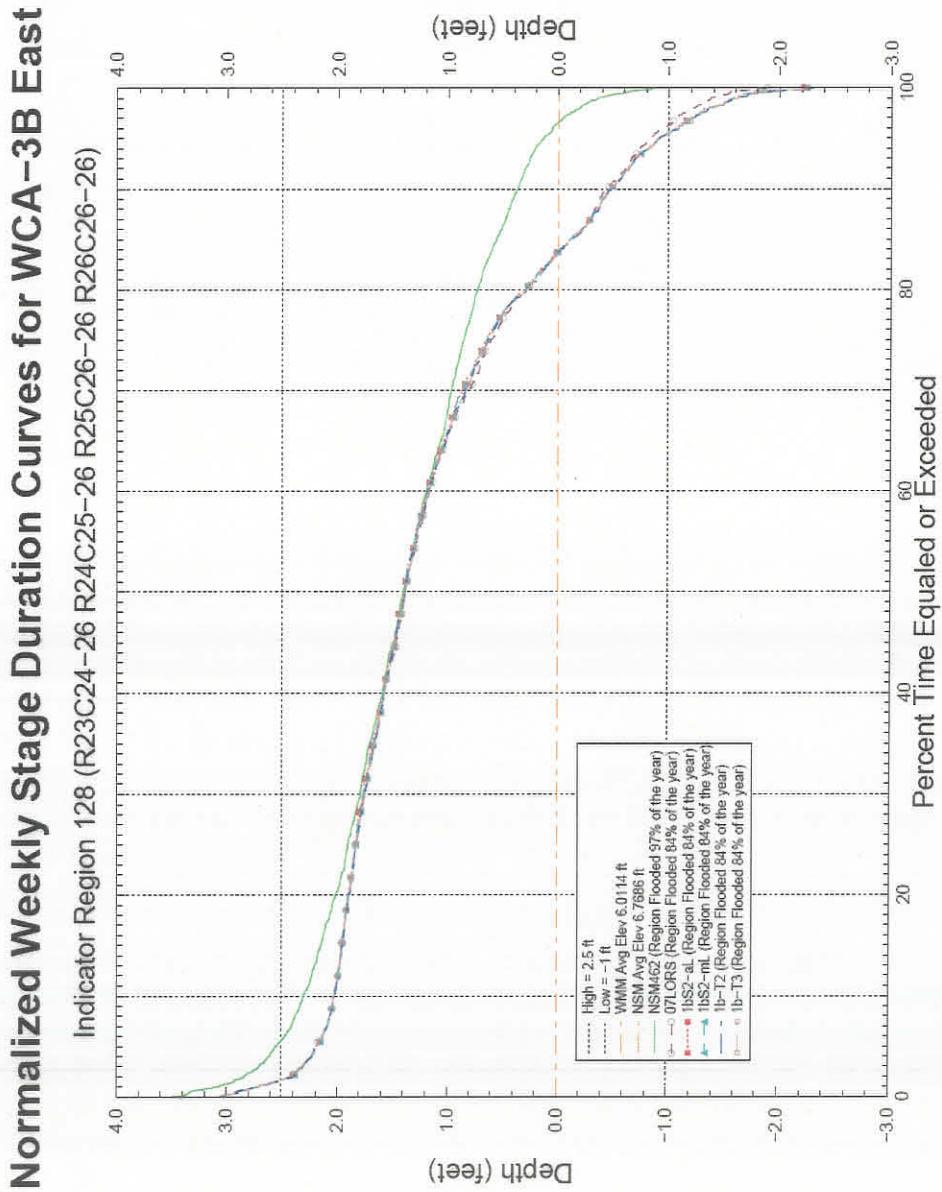


FIGURE C-66: STAGE DURATION CURVES FOR INDICATOR REGION 128, WCA-3B EAST (1)

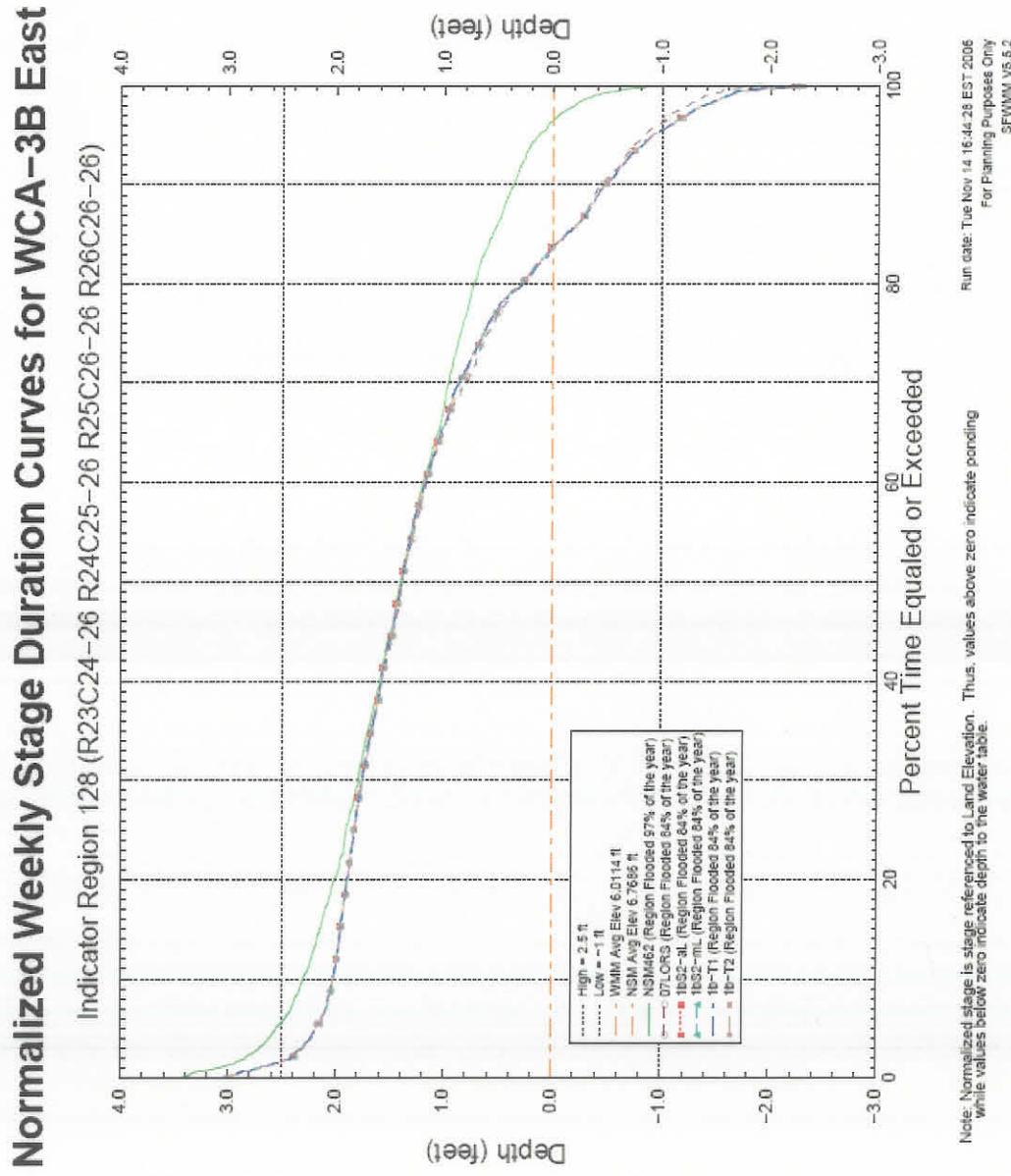
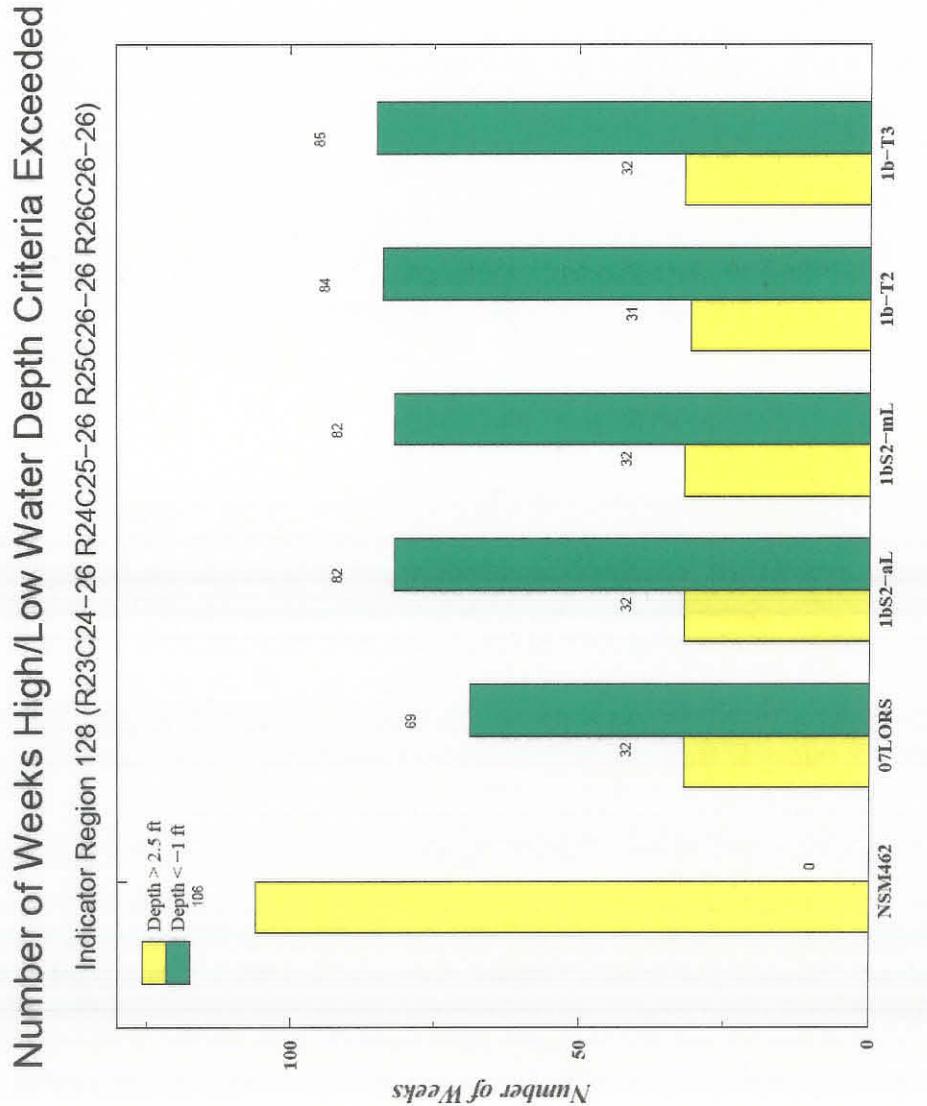
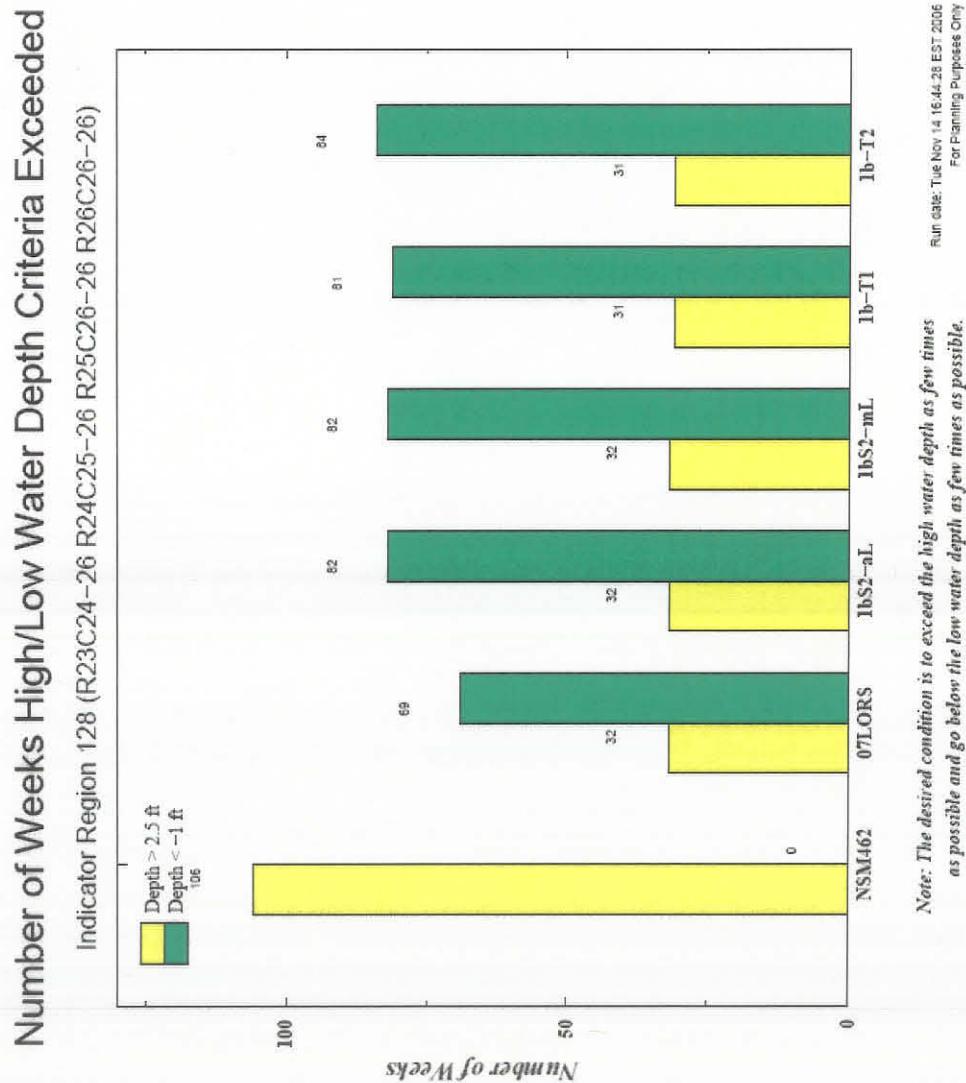


FIGURE C-67: STAGE DURATION CURVES FOR INDICATOR REGION 128, WCA-3B EAST (2)



**FIGURE C-68: HIGH AND LOW WATER DEPTH CRITERIA FOR INDICATOR REGION 128,
WCA-3B EAST (1)**



**FIGURE C-69: HIGH AND LOW WATER DEPTH CRITERIA FOR INDICATOR REGION 128,
WCA-3B EAST (2)**

Mean Annual EAA/LOSA Supplemental Irrigation Demands & Demands Not Met for 1965 – 2000

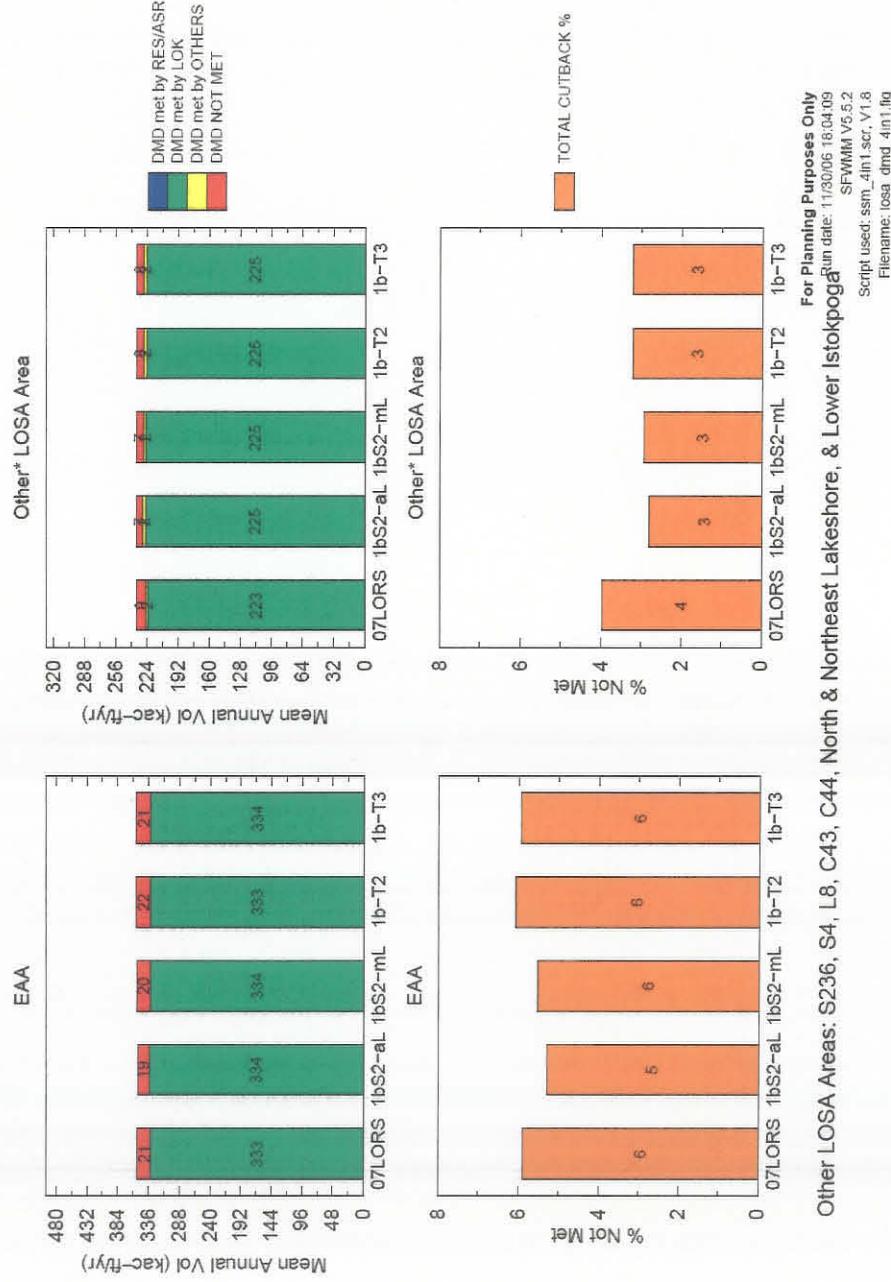


FIGURE C-70: MEAN ANNUAL EAA AND LOSA SUPPLEMENTAL IRRIGATION DEMANDS AND DEMANDS NOT MET, 1965-2000 (1)

Mean Annual EAA/LOSA Supplemental Irrigation Demands & Demands Not Met for 1965 – 2000

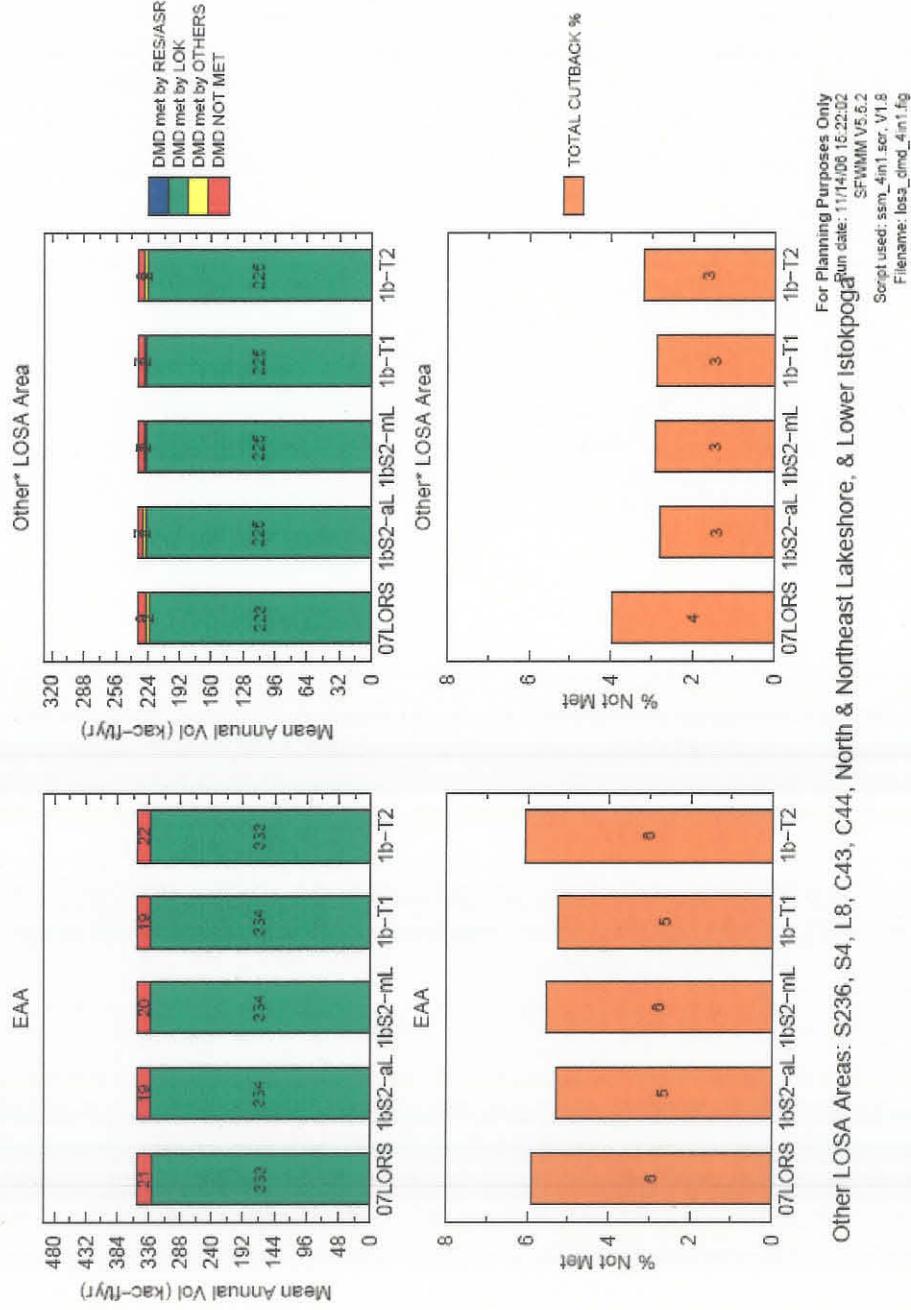


FIGURE C-71: MEAN ANNUAL EAA AND LOSA SUPPLEMENTAL IRRIGATION DEMANDS AND DEMANDS NOT MET, 1965-2000 (2)

For Planning Purposes Only
Run date: 11/14/06 15:22:02
SFWMW V5.5.2
Script used: ssm_4in1.scr, V1.8
Filename: losa_dmd_4in1.frg

Other LOSA Areas: S236, S4, L8, C43, C44, North & Northeast Lakeshore, & Lower Istokpoga

**Mean Annual EAA/LOSA Supplemental Irrigation:
Demands & Demands Not Met from 1965 – 2000
For Drought Years: 1971 1975 1981 1985 1989**

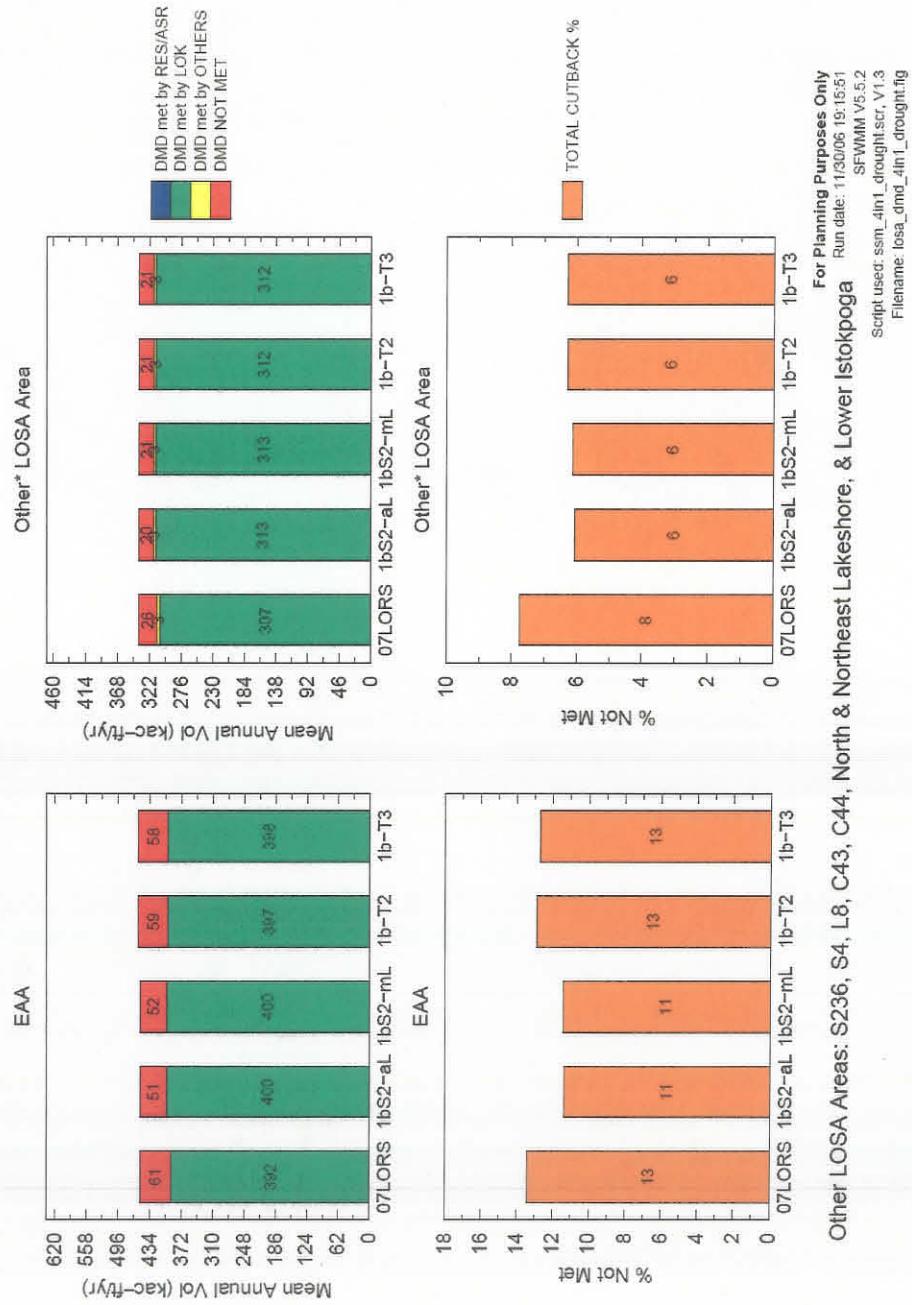


FIGURE C-72: MEAN ANNUAL EAA AND LOSA SUPPLEMENTAL IRRIGATION DEMANDS AND DEMANDS NOT MET, 1965-2000 DROUGHT YEARS (1)

Mean Annual EAA/LOSA Supplemental Irrigation Demands & Demands Not Met from 1965 – 2000 For Drought Years: 1971 1975 1981 1985 1989

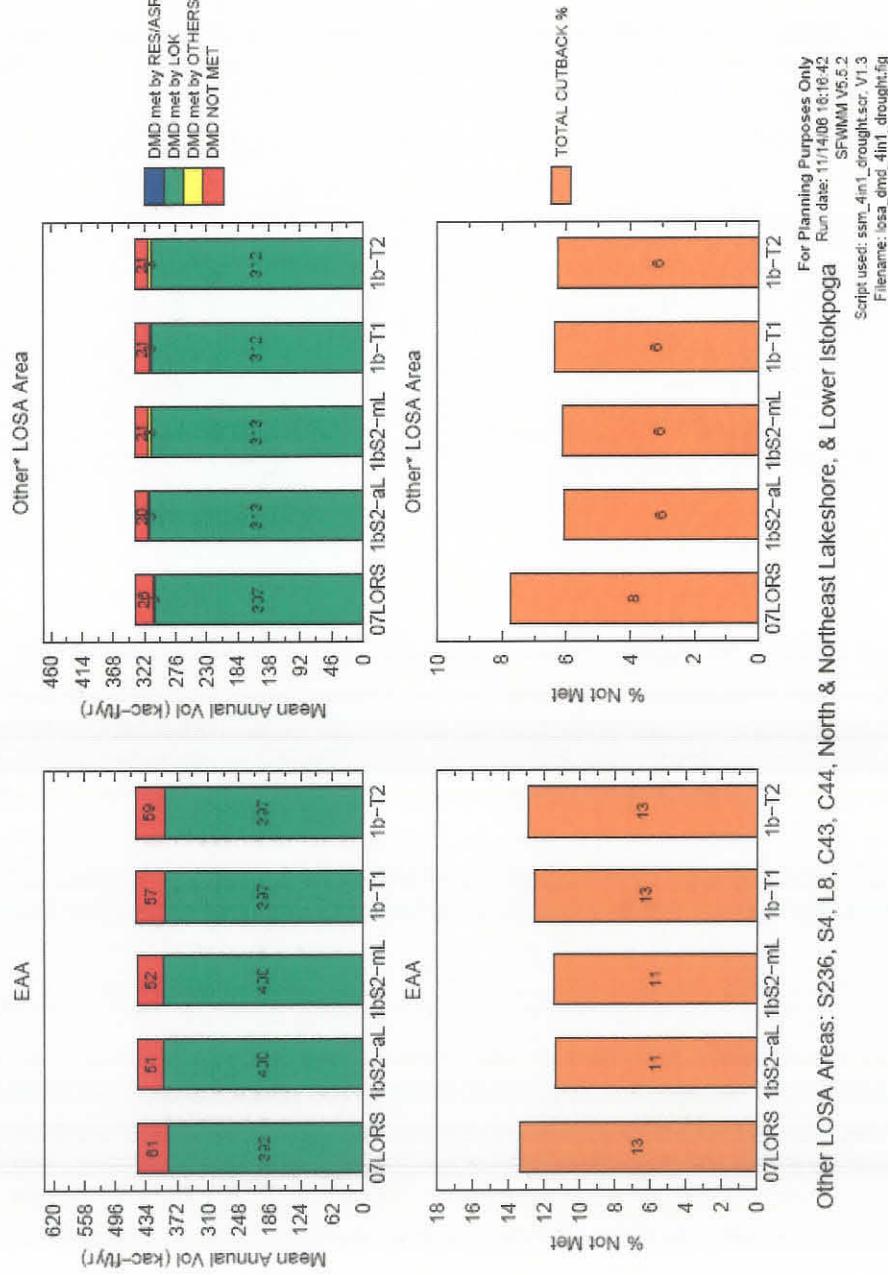


FIGURE C-73: MEAN ANNUAL EAA AND LOSA SUPPLEMENTAL IRRIGATION DEMANDS AND DEMANDS NOT MET, 1965-2000 DROUGHT YEARS (2)

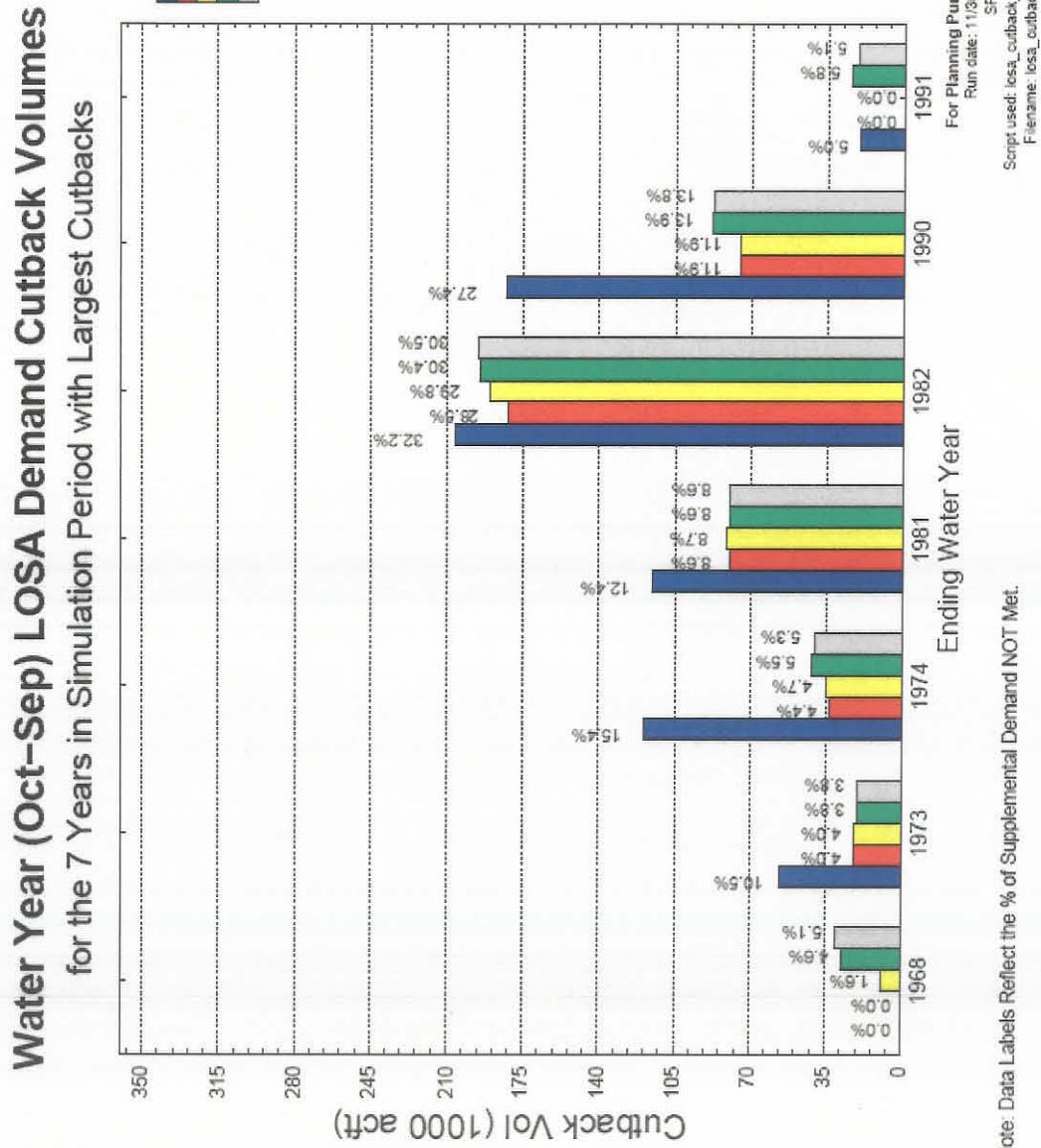


FIGURE C-74: WATER YEAR LOSA DEMAND CUTBACK VOLUMES, 7 DROUGHT YEARS (1)

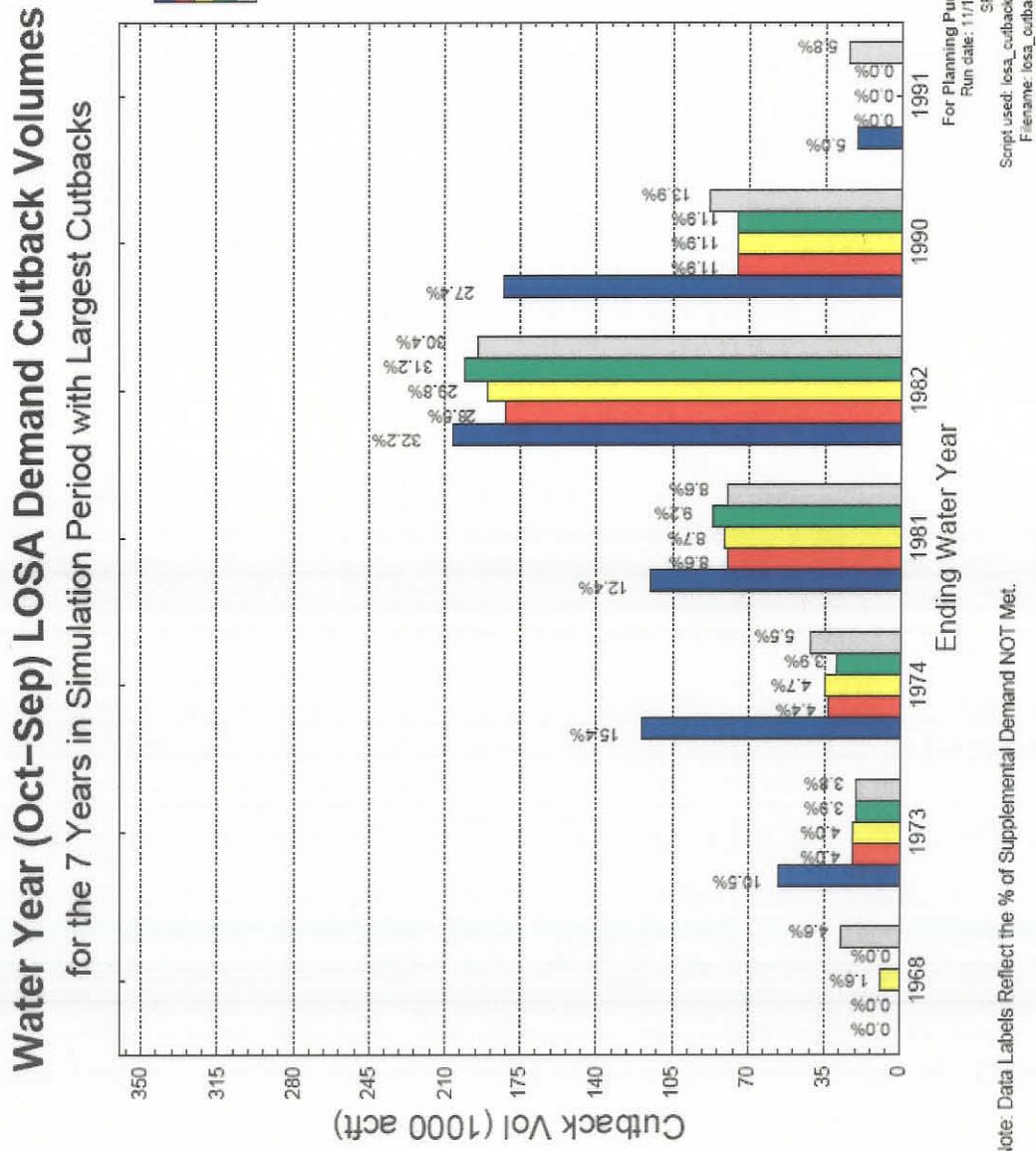
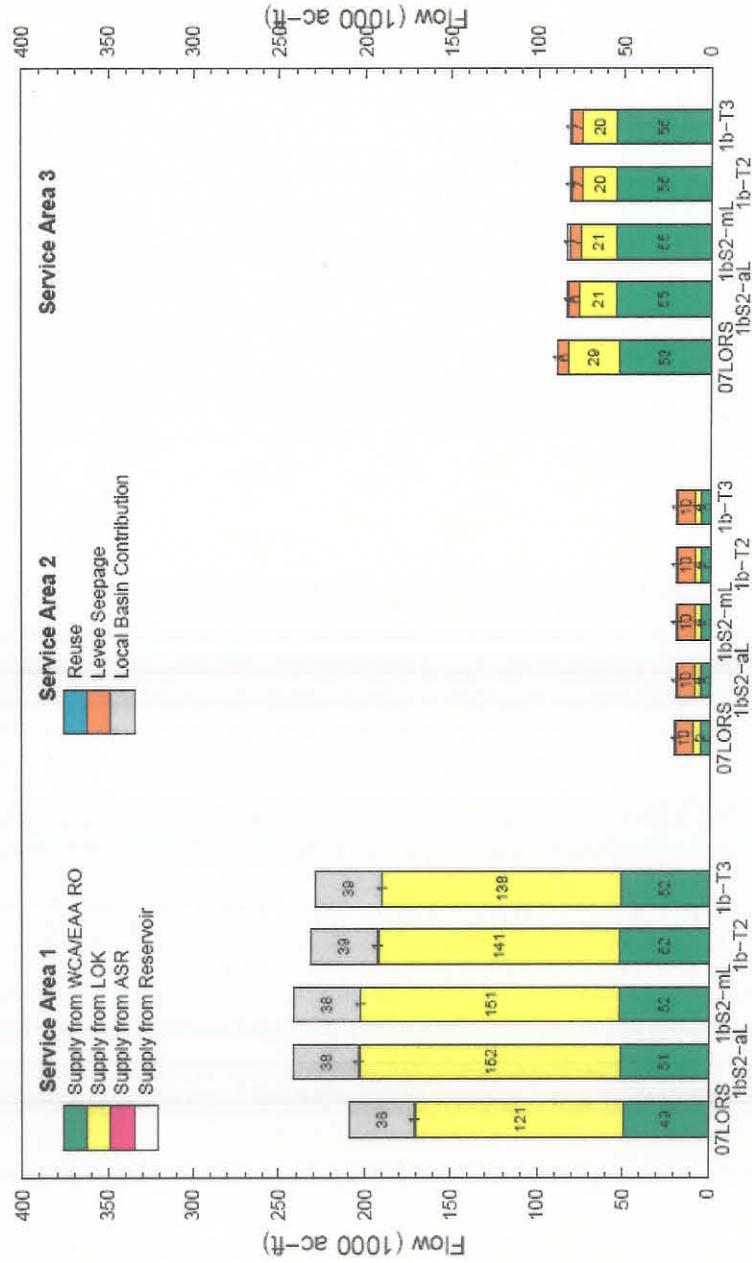


FIGURE C-75: WATER YEAR LOSA DEMAND CUTBACK VOLUMES, 7 DROUGHT YEARS (2)

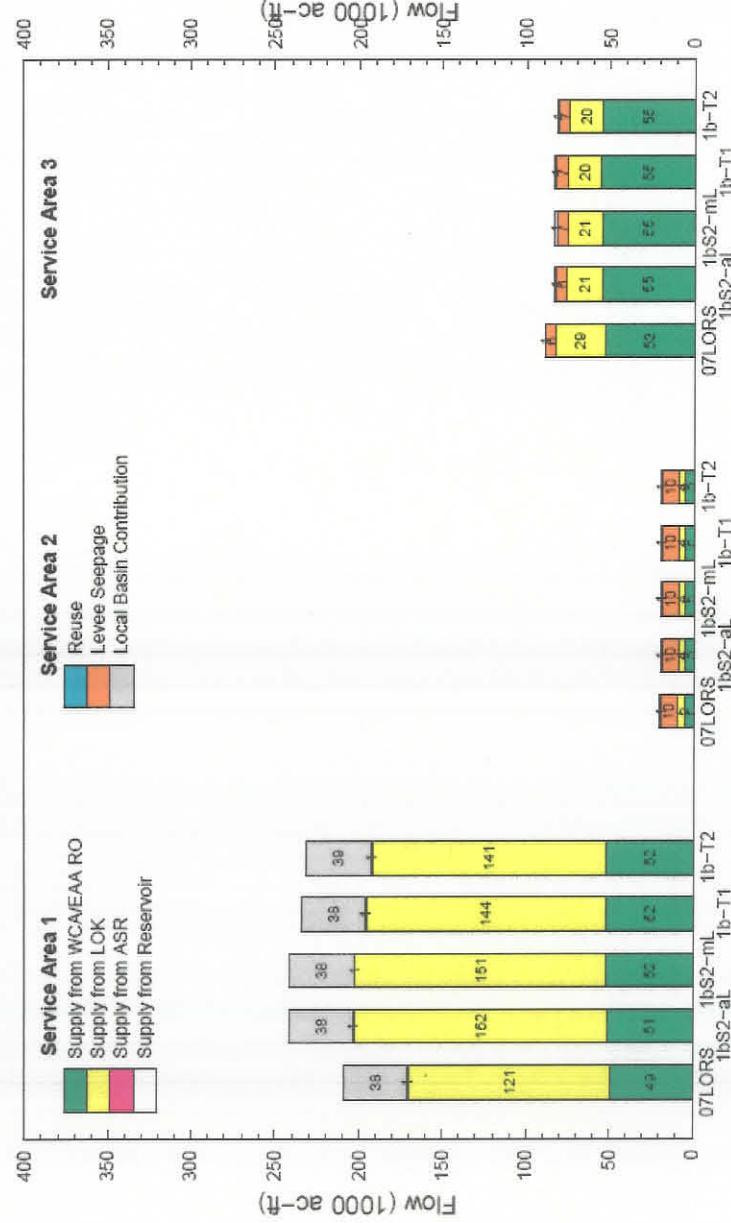
Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 – 2000 simulation



For Planning Purposes Only
Run date: 11/30/06 10:15:33
SFWMW Ver 5.2
Script used: wsupplies_comps.scr_V5.2
Filename: lec_ws_barfig

FIGURE C-76: AVERAGE ANNUAL REGIONAL WATER SUPPLY DELIVERIES TO LOWER EAST COAST SERVICE AREAS, 1965-2000 (1)

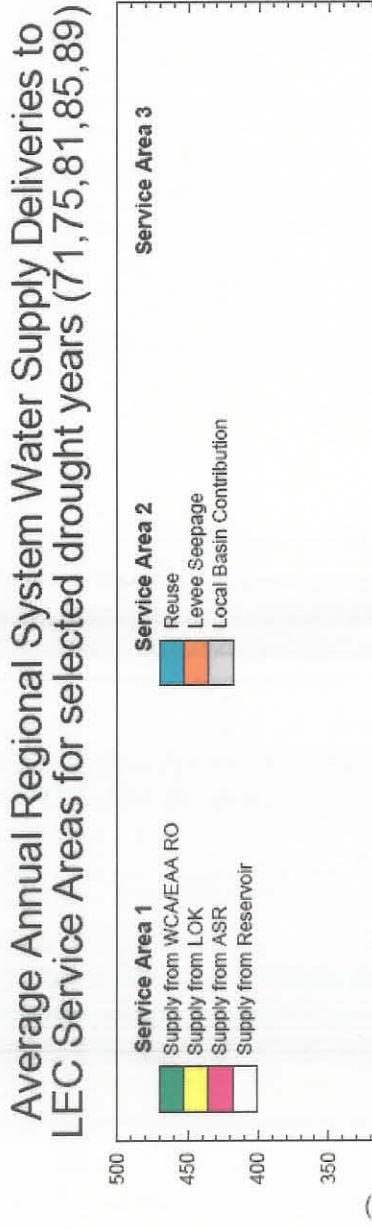
Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 – 2000 simulation



Note: Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAAs.

For Planning Purposes Only
Run date: 11/14/00 10:18:30
SFWMW Version 5.2
Script used: wsupply2as_comscr_v1.3
Filename: lec_ws_bar.flg

FIGURE C-77: AVERAGE ANNUAL REGIONAL WATER SUPPLY DELIVERIES TO LOWER EAST COAST SERVICE AREAS, 1965-2000 (2)

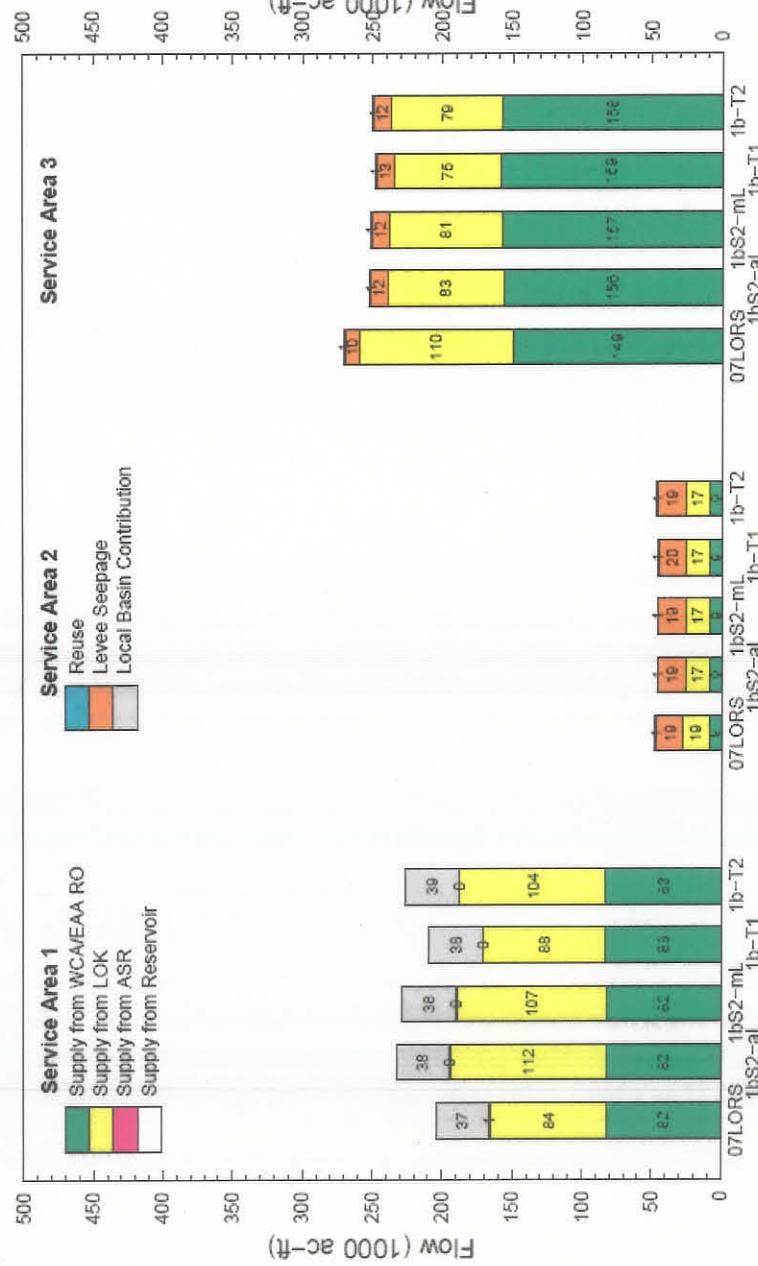


Note: Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCs.

For Planning Purposes Only
Run Date: 11/20/06 16:18:07
SFWMW Version 5.5.2
Script used: wsupp2sa_comps.ser, V1.3
Filename: lec_ws_droughts_bar.fig

FIGURE C-78: AVERAGE ANNUAL REGIONAL WATER SUPPLY DELIVERIES TO LOWER EAST COAST SERVICE AREAS, 1965-2000 DROUGHT YEARS (1)

Average Annual Regional System Water Supply Deliveries to LEC Service Areas for selected drought years (71,75,81,85,89)



Note: Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCA's.

For Planning Purposes Only
Run date: 11/14/06 16:18:58
Script used: wsupply2a_comscr_v1.3
Filename: leo_lws_droughts_bar.fig

FIGURE C-79: AVERAGE ANNUAL REGIONAL WATER SUPPLY DELIVERIES TO LOWER EAST COAST SERVICE AREAS, 1965-2000 DROUGHT YEARS (2)

**Number of Months of Simulated Water Supply Cutbacks
for the 1965 – 2000 Simulation Period**

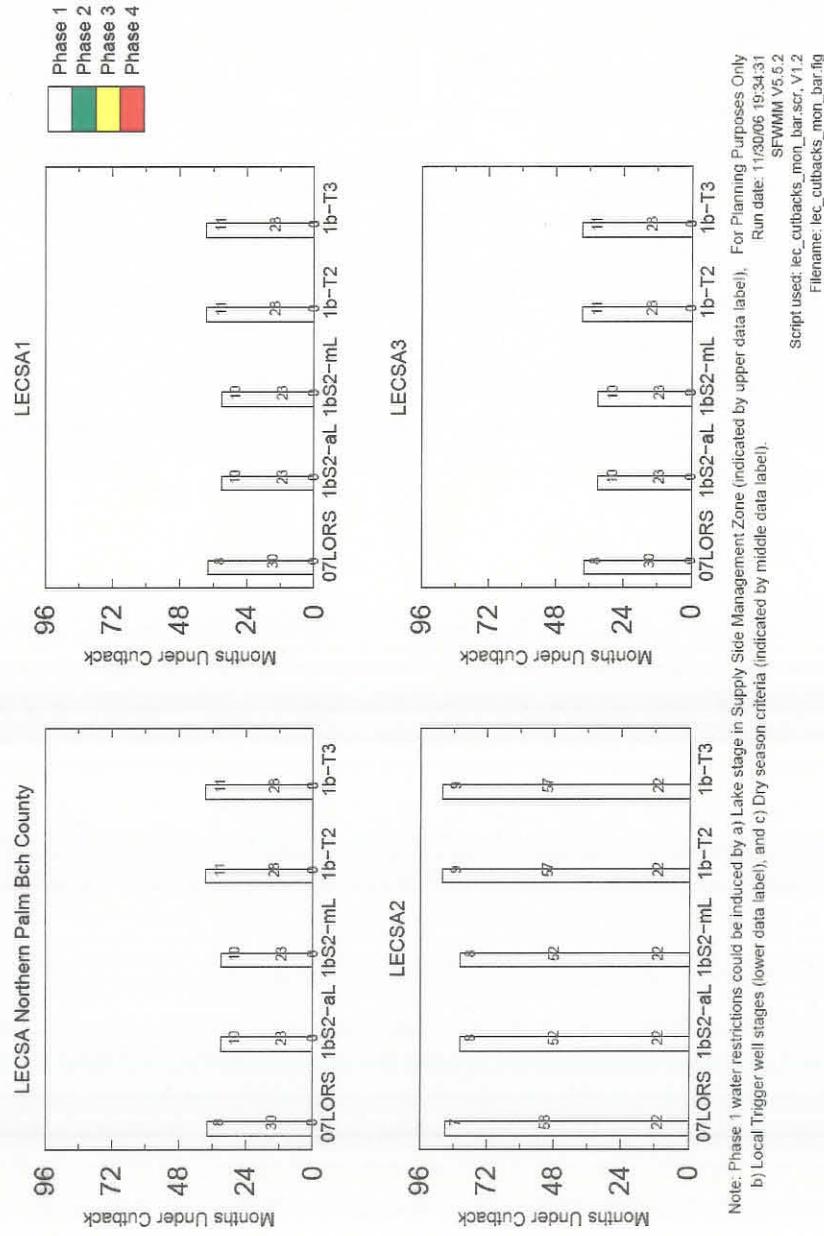
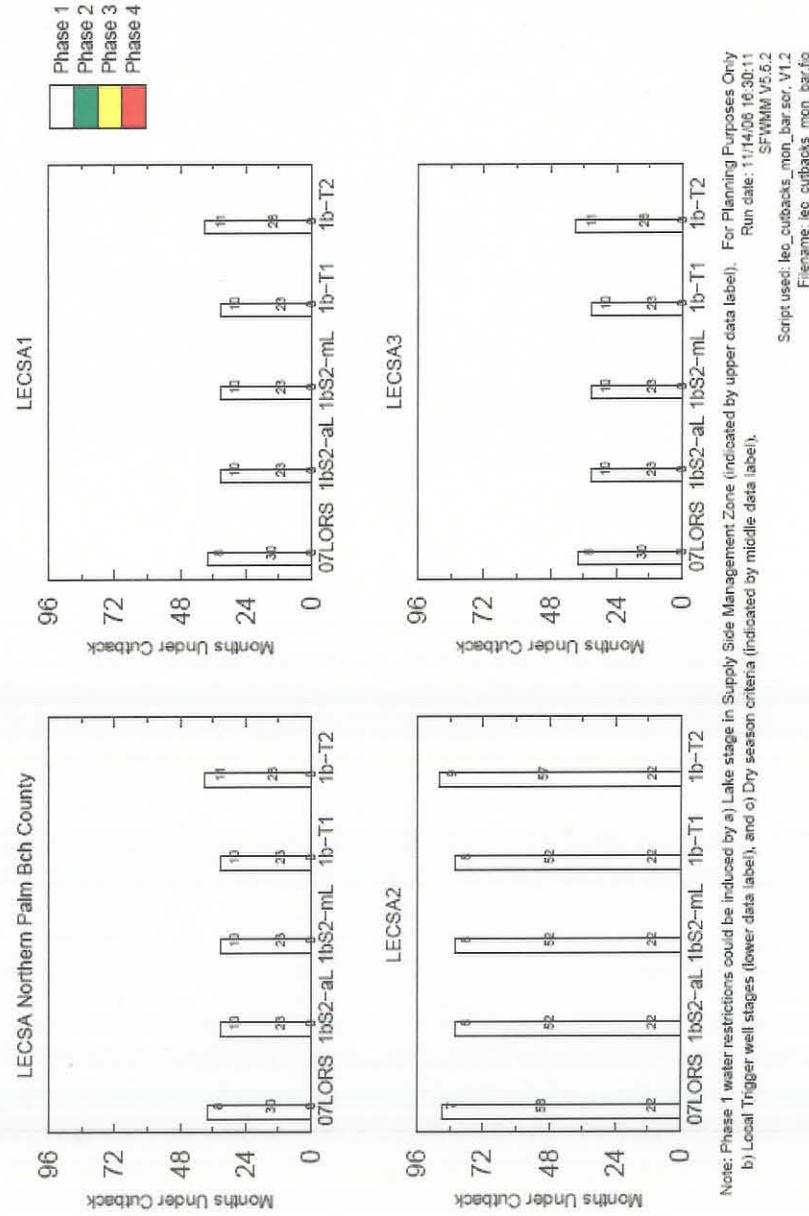


FIGURE C-80: MONTHS OF SIMULATED WATER SUPPLY CUTBACKS FOR LOWER EAST COAST SERVICE AREAS (1)

**Number of Months of Simulated Water Supply Cutbacks
for the 1965 – 2000 Simulation Period**



**FIGURE C-81: MONTHS OF SIMULATED WATER SUPPLY CUTBACKS FOR
LOWER EAST COAST SERVICE AREAS (2)**

Annual Average (1965 – 2000) Irrigation Supplies and Shortages for the Seminole Tribe – Brighton Reservation

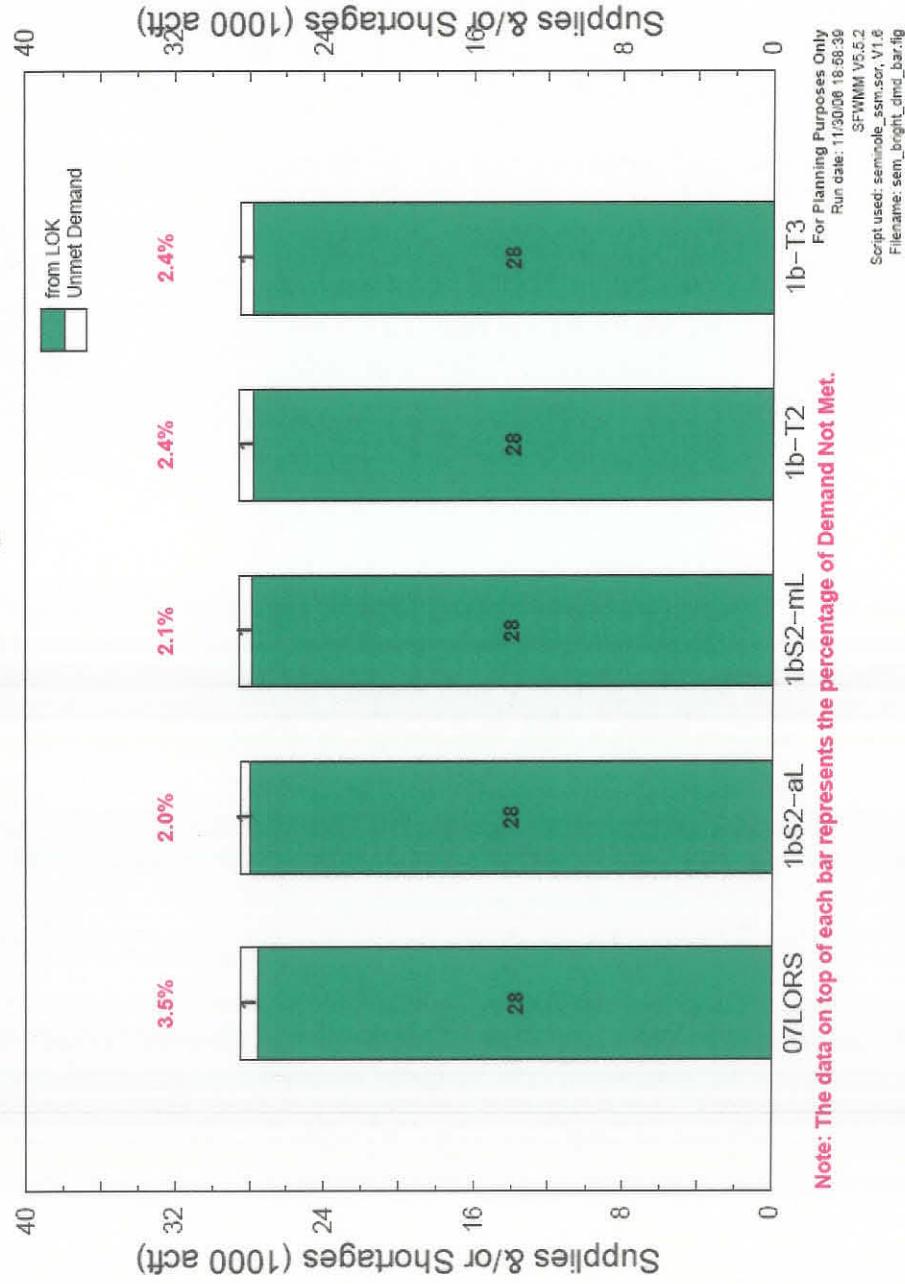


FIGURE C-82: AVERAGE ANNUAL SIMULATED IRRIGATION SUPPLIES AND SHORTAGES FOR THE SEMINOLE TRIBE – BRIGHTON RESERVATION (1)

Annual Average (1965 – 2000) Irrigation Supplies and Shortages for the Seminole Tribe – Brighton Reservation

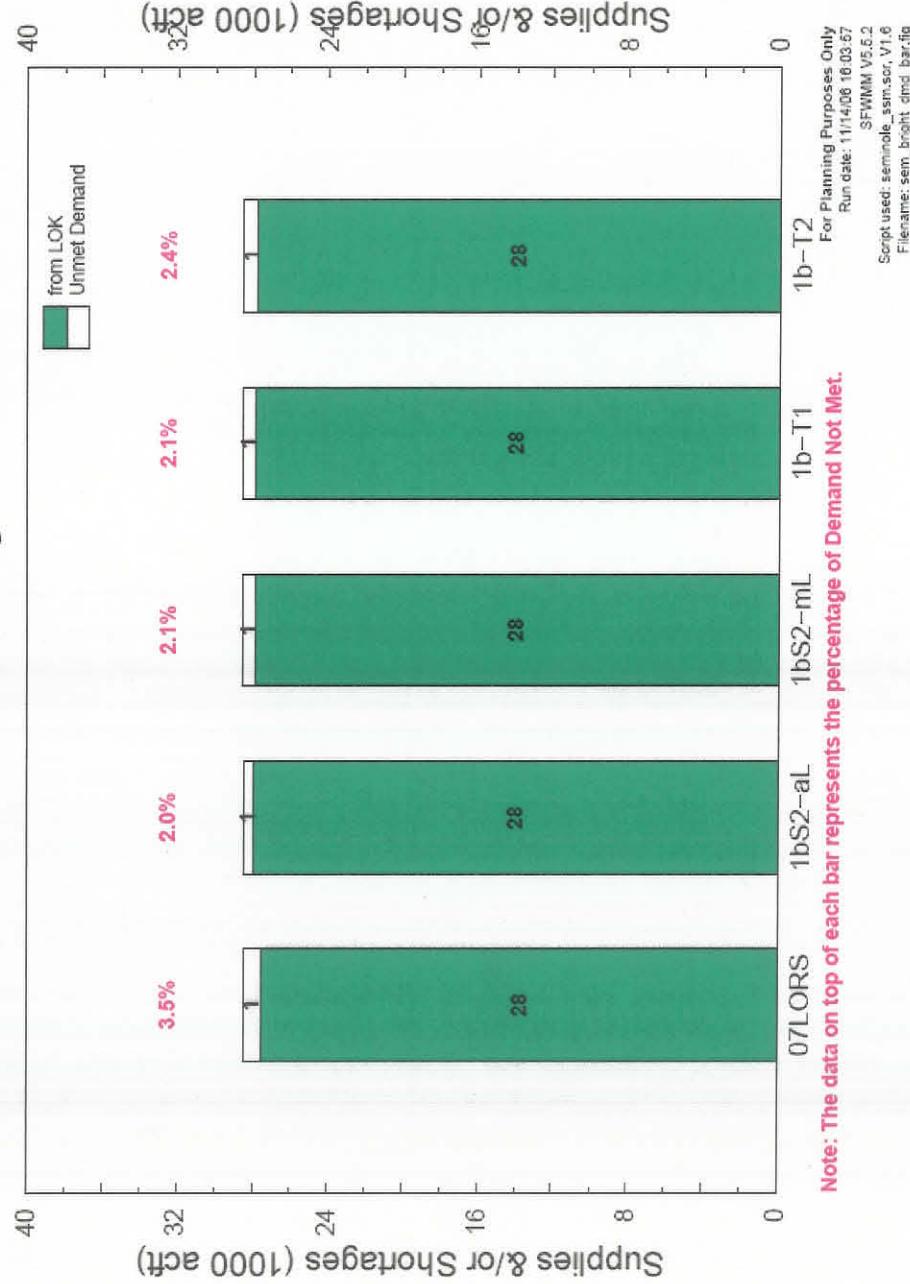


FIGURE C-83: AVERAGE ANNUAL SIMULATED IRRIGATION SUPPLIES AND SHORTAGES FOR THE SEMINOLE TRIBE – BRIGHTON RESERVATION (2)

Annual Average (1965 – 2000) Irrigation Supplies and Shortages for the Seminole Tribe – Big Cypress Reservation

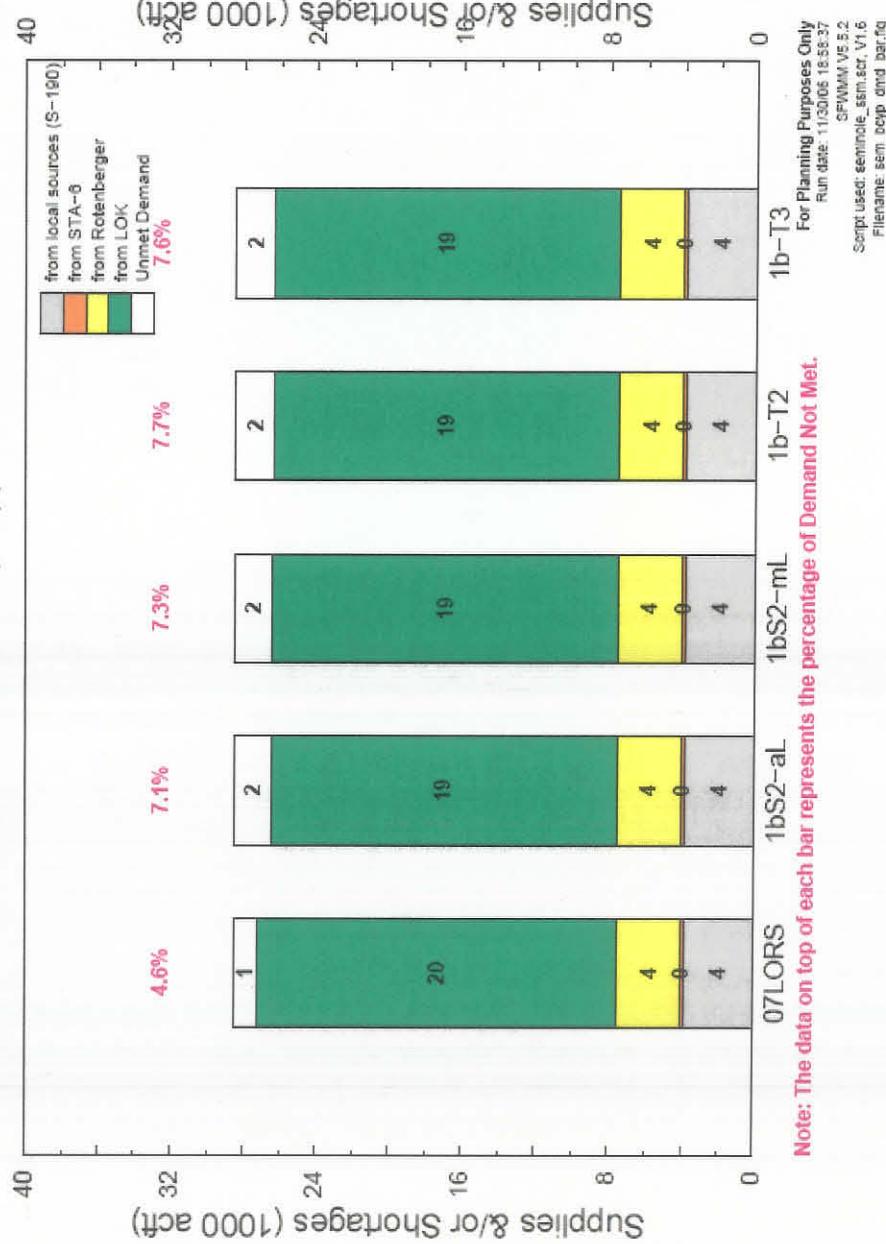


FIGURE C-84: AVERAGE ANNUAL SIMULATED IRRIGATION SUPPLIES AND SHORTAGES FOR THE SEMINOLE TRIBE – BIG CYPRESS RESERVATION (1)

Annual Average (1965 – 2000) Irrigation Supplies and Shortages for the Seminole Tribe – Big Cypress Reservation

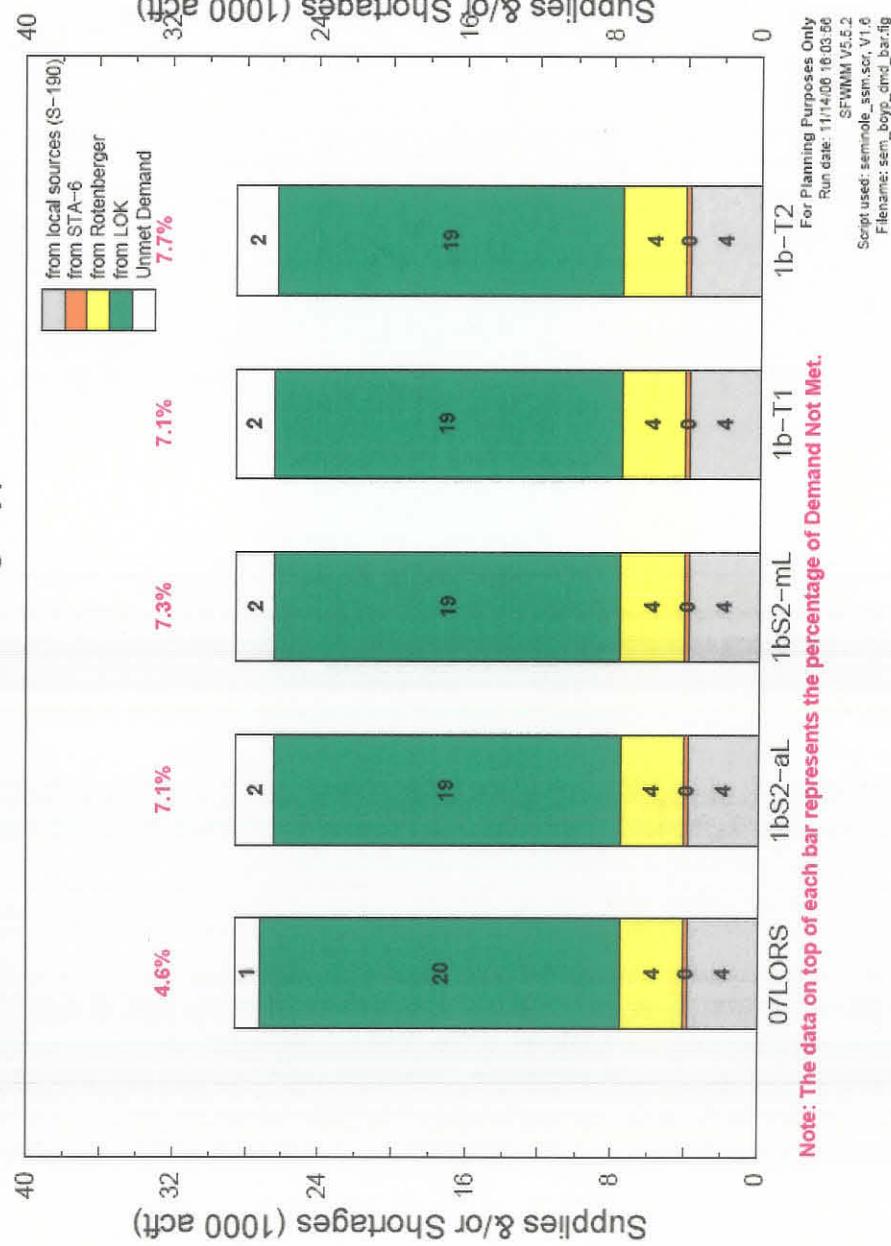


FIGURE C-85: AVERAGE ANNUAL SIMULATED IRRIGATION SUPPLIES AND SHORTAGES FOR THE SEMINOLE TRIBE – BIG CYPRESS RESERVATION (2)

Mean Annual EAA/LOSA Supplemental Irrigation Demands & Demands Not Met for 1965 – 2000

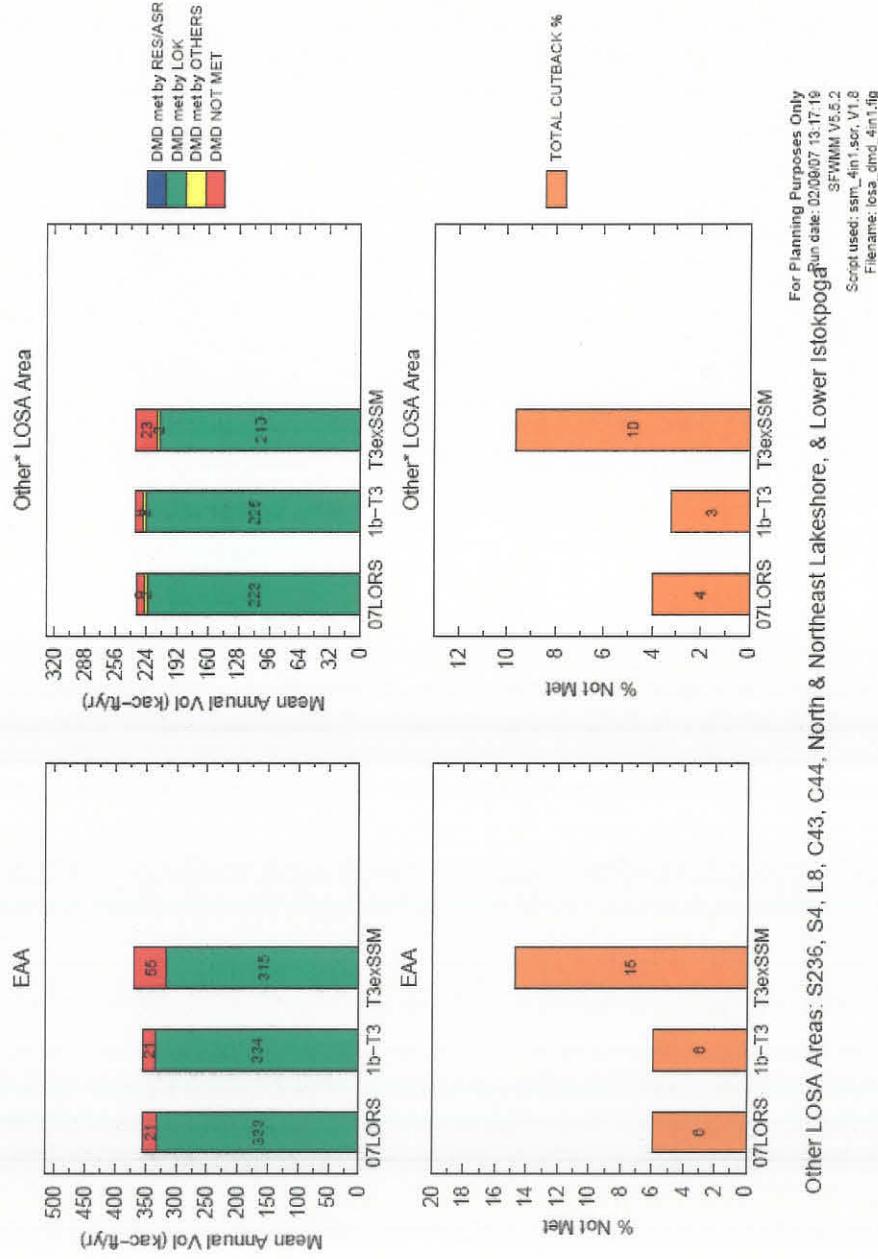


FIGURE C-86: MEAN ANNUAL EAA AND LOSA SUPPLEMENTAL IRRIGATION DEMANDS AND DEMANDS NOT MET, 1965-2000 (SSM SENSITIVITY SIMULATION)

**Mean Annual EAA/LOSA Supplemental Irrigation:
Demands & Demands Not Met from 1965 – 2000
For Drought Years: 1971 1975 1981 1985 1989**

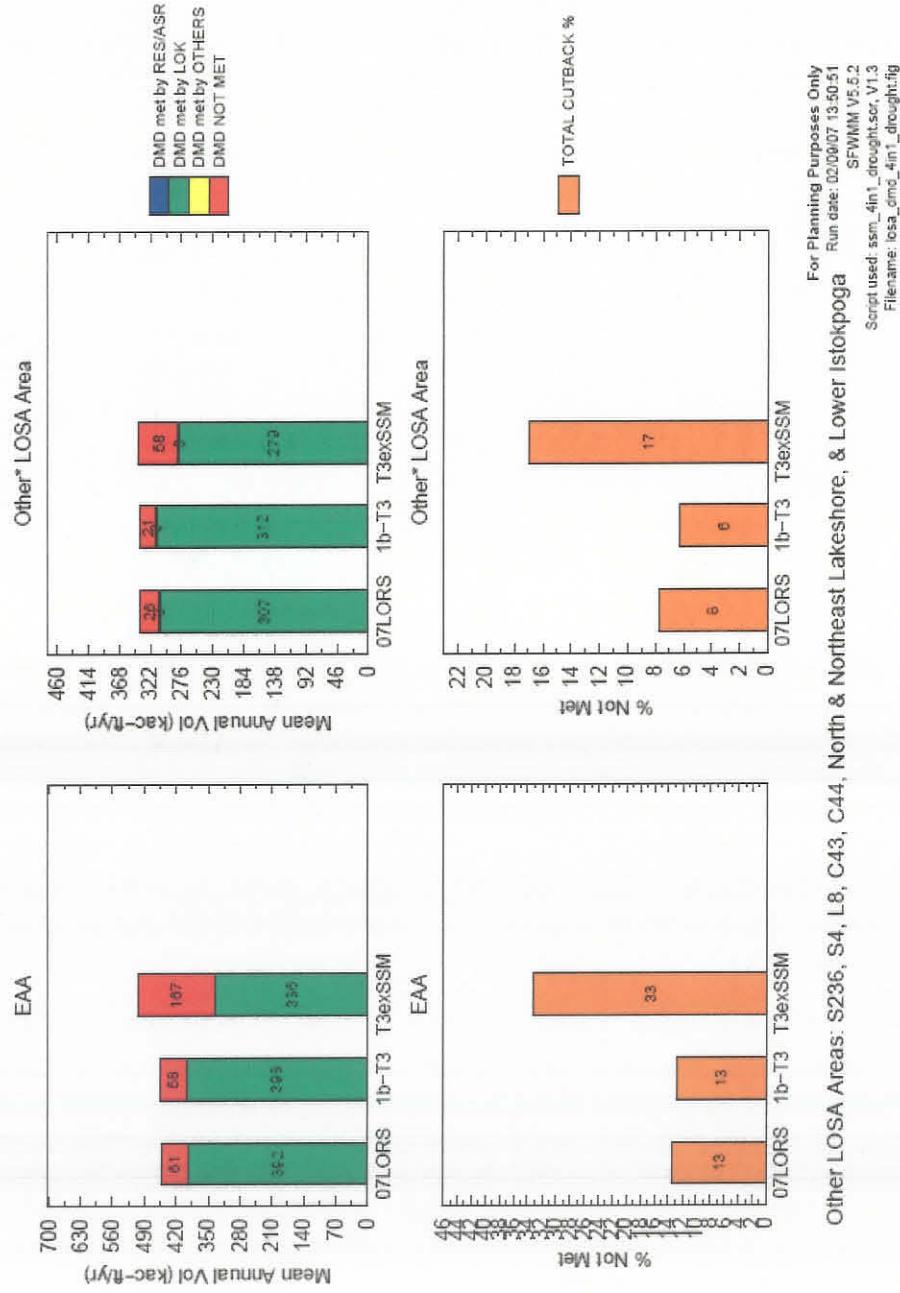
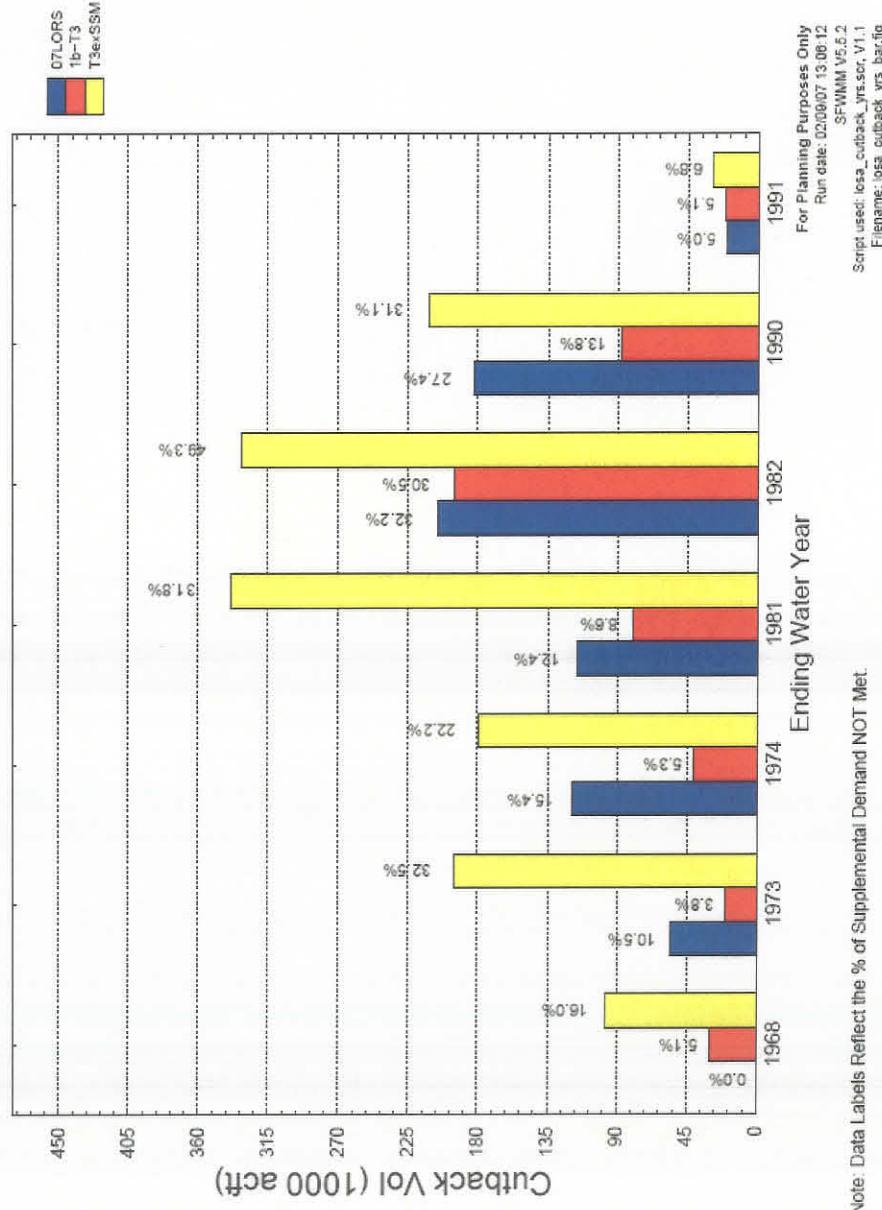


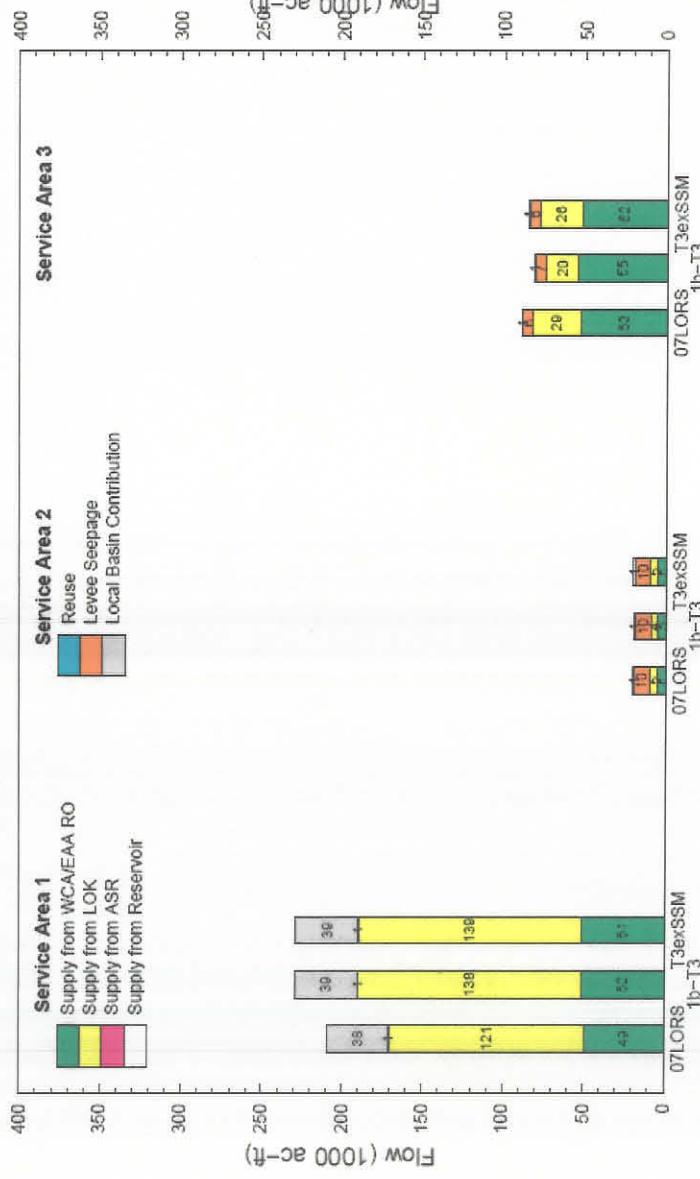
FIGURE C-87: MEAN ANNUAL EAA AND LOSA SUPPLEMENTAL IRRIGATION DEMANDS AND DEMANDS NOT MET, 1965-2000 DROUGHT YEARS (SSM SENSITIVITY SIMULATION)

**Water Year (Oct–Sep) LOSA Demand Cutback Volumes
for the 7 Years in Simulation Period with Largest Cutbacks**



**FIGURE C-38: WATER YEAR LOSA DEMAND CUTBACK VOLUMES, 7 DROUGHT YEARS
(SSM SENSITIVITY SIMULATION)**

Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 – 2000 simulation

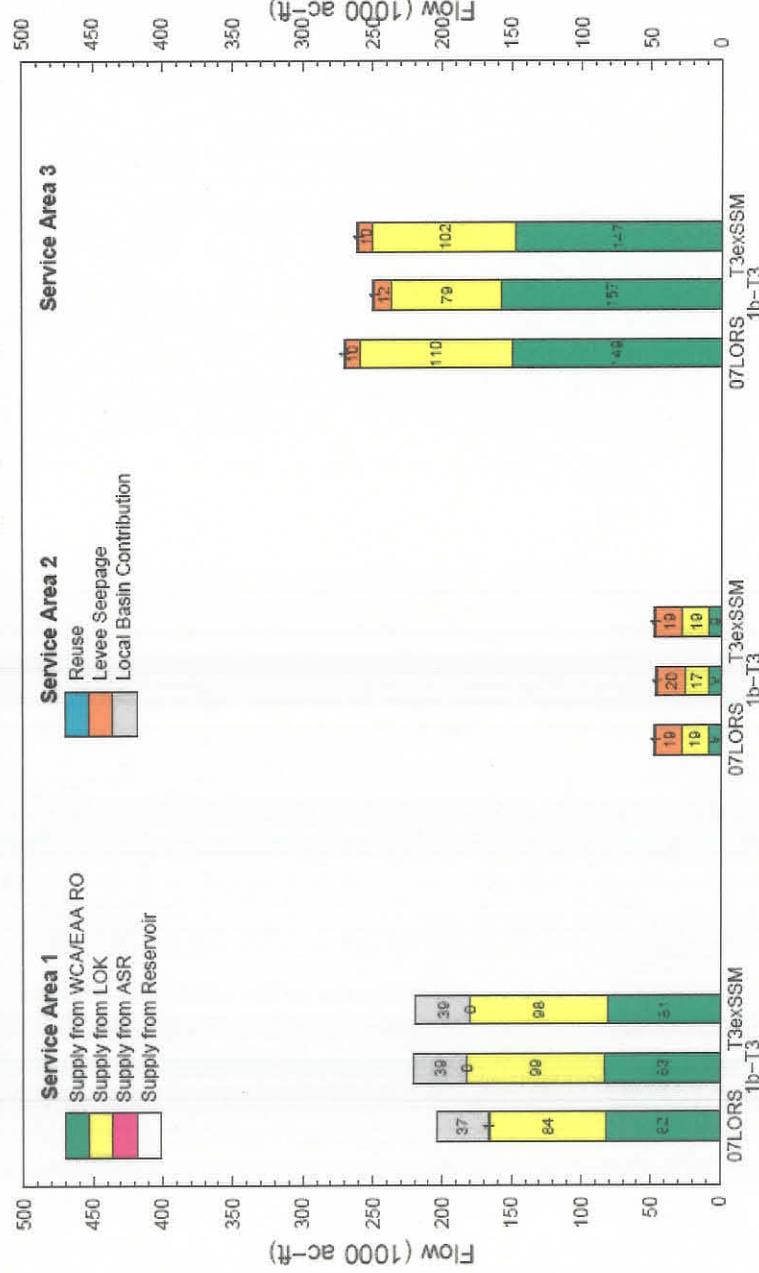


Note: Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

For Planning Purposes Only
Run date: 2010/07/13 6:15:09
Script used: wssup2ca_LoneIsr_v1.3
Filename: lec_ws_bar.flg

FIGURE C-89: AVERAGE ANNUAL REGIONAL WATER SUPPLY DELIVERIES TO LOWER EAST COAST SERVICE AREAS, 1965-2000 (SSM SENSITIVITY SIMULATION)

Average Annual Regional System Water Supply Deliveries to LEC Service Areas for selected drought years (71,75,81,85,89)



Note: Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCA.

For Planning Purposes Only
Run date: 12/10/07 13:50:01
SFWMW V5.5.2
Script used: wsipc2sa_compcscr_v1.3
Filename: lec_ws_droughts_bar4g

FIGURE C-90: AVERAGE ANNUAL REGIONAL WATER SUPPLY DELIVERIES TO LOWER EAST COAST SERVICE AREAS, 1965-2000 DROUGHT YEARS (SSM SENSITIVITY SIMULATION)

**Number of Months of Simulated Water Supply Cutbacks
for the 1965 – 2000 Simulation Period**

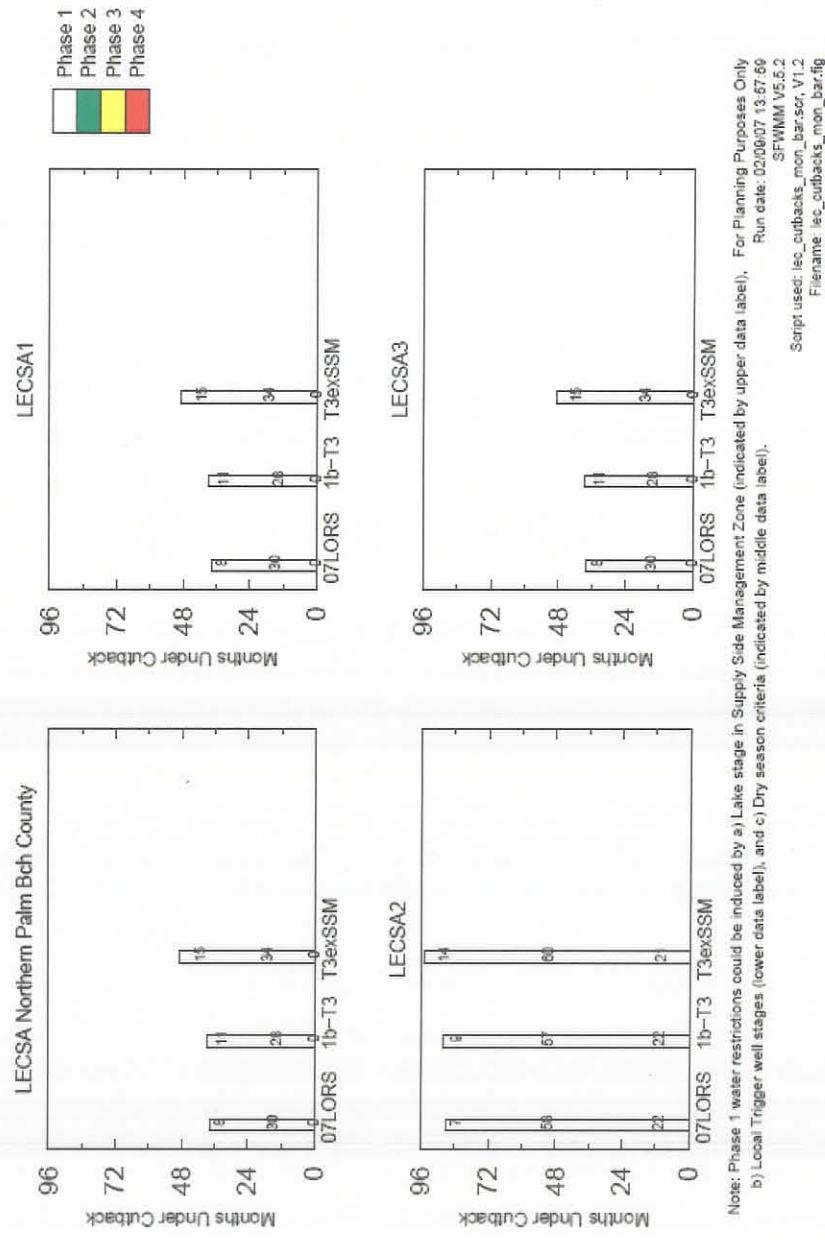


FIGURE C-91: MONTHS OF SIMULATED WATER SUPPLY CUTBACKS FOR LOWER EAST COAST SERVICE AREAS (SSM SENSITIVITY SIMULATION)

Annual Average (1965 – 2000) Irrigation Supplies and Shortages for the Seminole Tribe – Brighton Reservation



FIGURE C-92: AVERAGE ANNUAL SIMULATED IRRIGATION SUPPLIES AND SHORTAGES FOR THE SEMINOLE TRIBE – BRIGHTON RESERVATION (SSM SENSITIVITY SIMULATION)

Annual Average (1965 – 2000) Irrigation Supplies and Shortages for the Seminole Tribe – Big Cypress Reservation

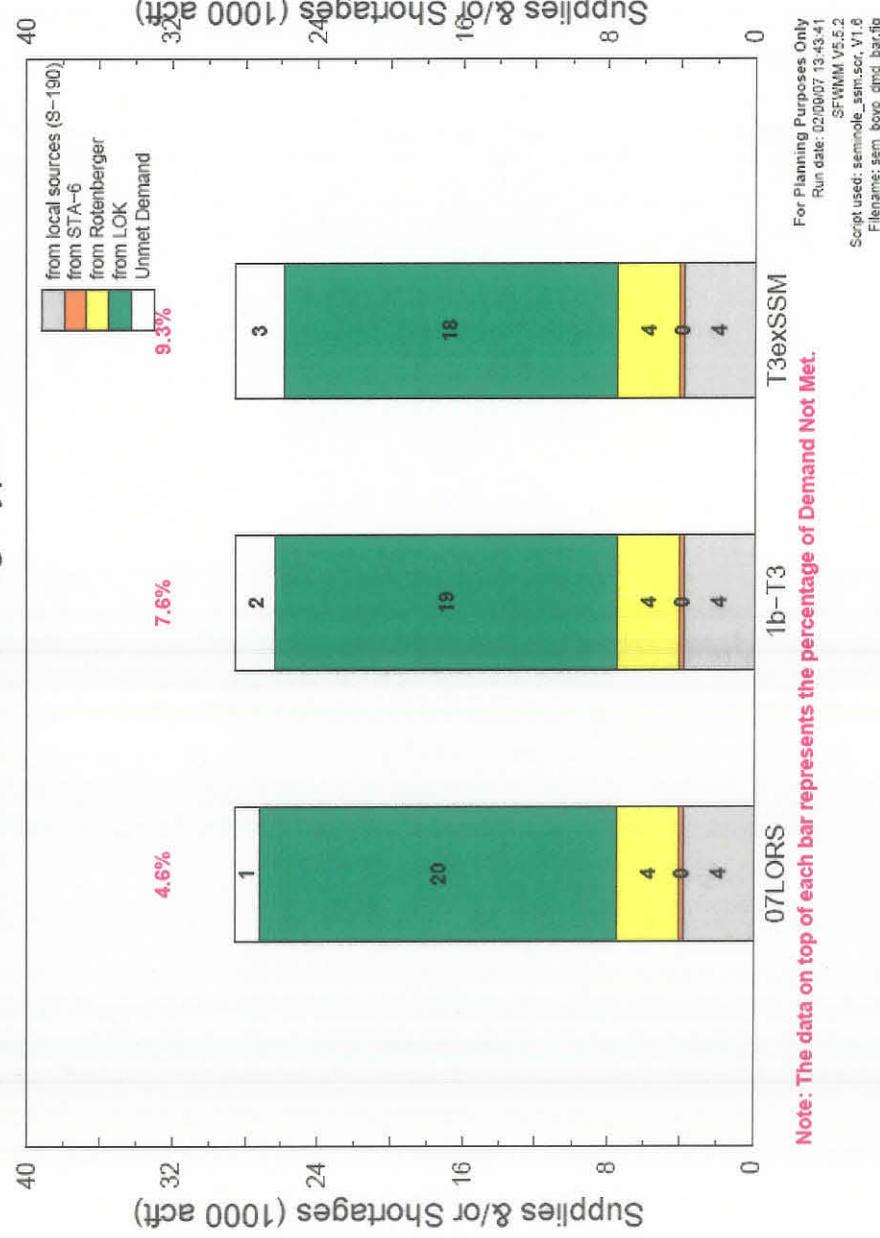


FIGURE C-93: AVERAGE ANNUAL SIMULATED IRRIGATION SUPPLIES AND SHORTAGES FOR THE SEMINOLE TRIBE – BIG CYPRESS RESERVATION (SSM SENSITIVITY SIMULATION)

End of Month Stage Duration Curves for Cell Row 40 Col 34 in the LEC

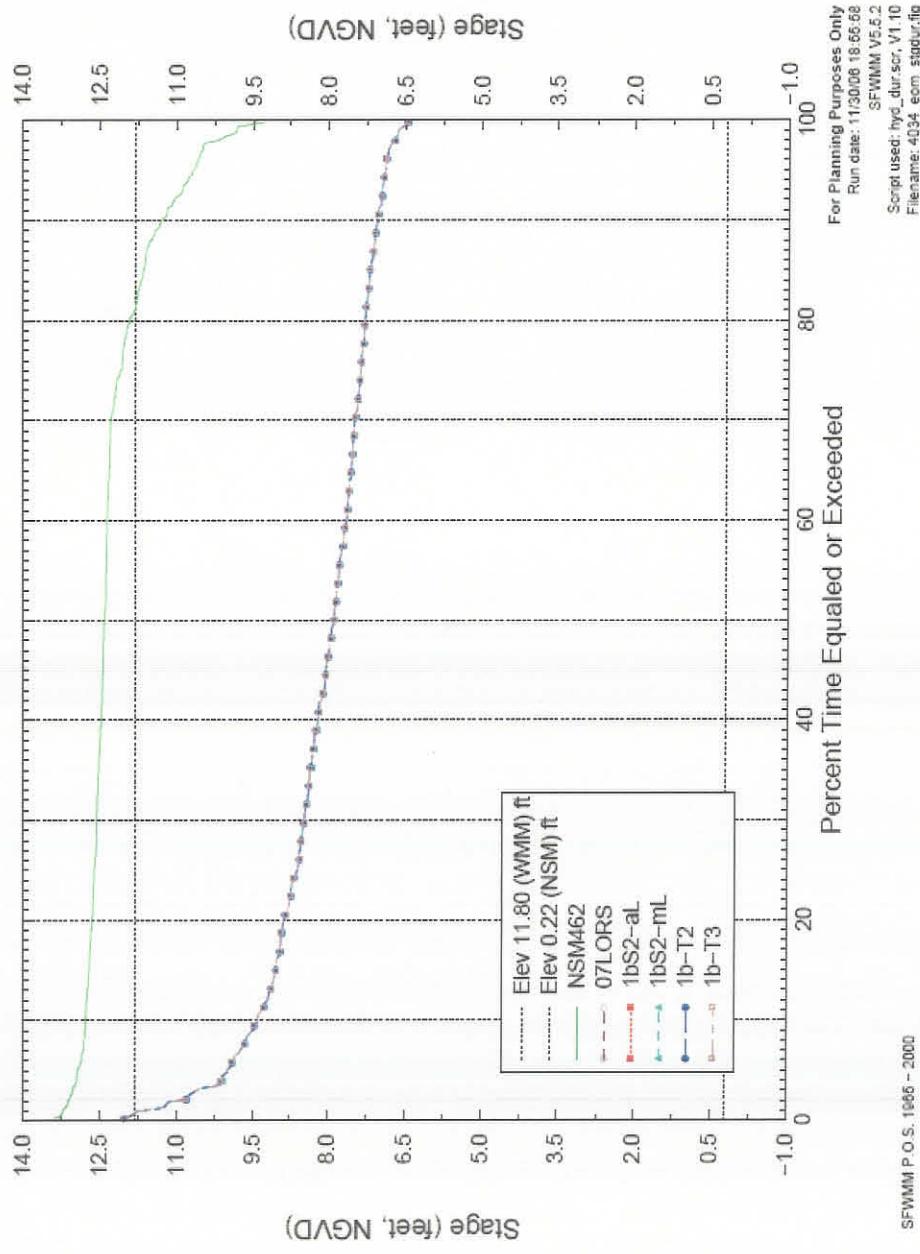


FIGURE C-94: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 40 COLUMN 34 (1)

End of Month Stage Duration Curves for Cell Row 40 Col 34 in the LEC

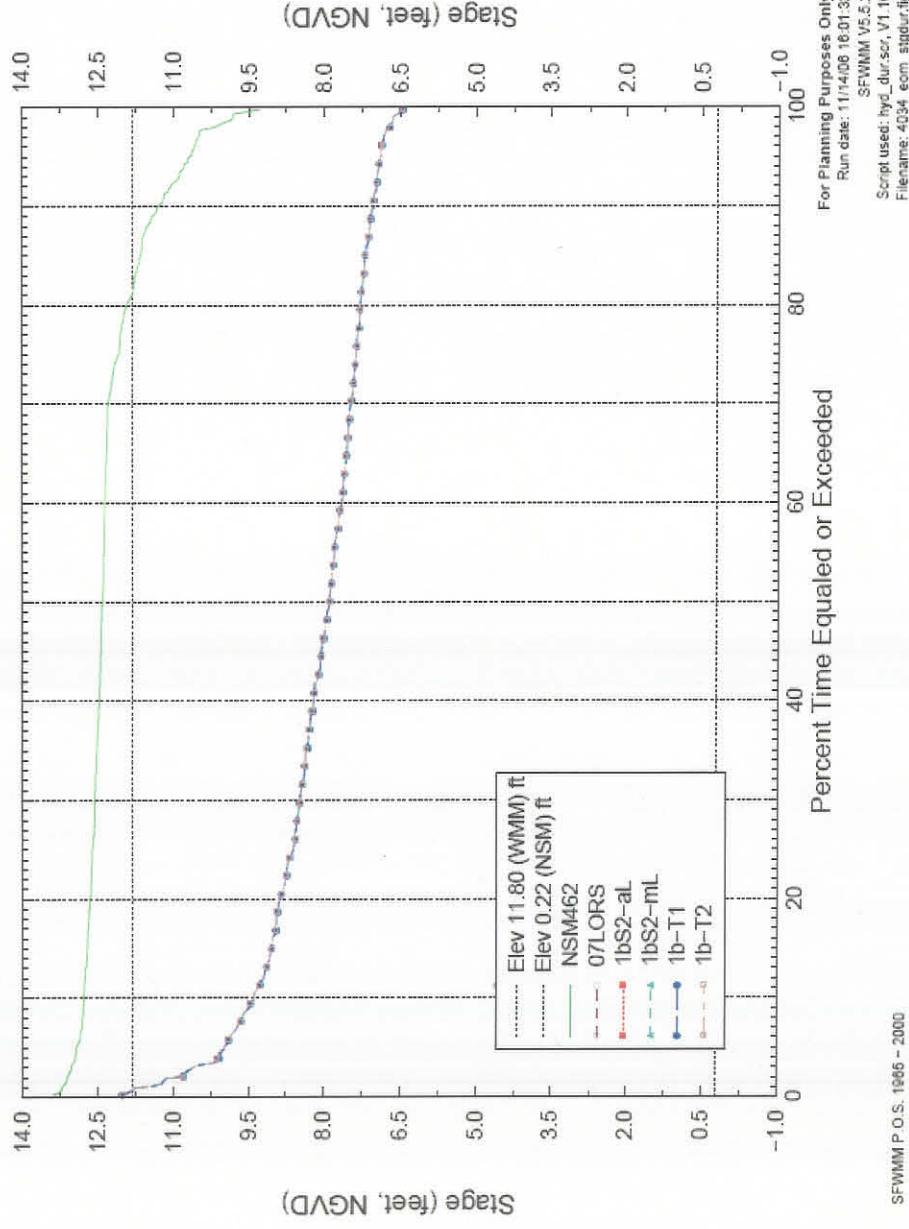


FIGURE C-95: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 40 COLUMN 34 (2)

End of Month Stage Duration Curves for Cell Row 35 Col 33 in the LEC

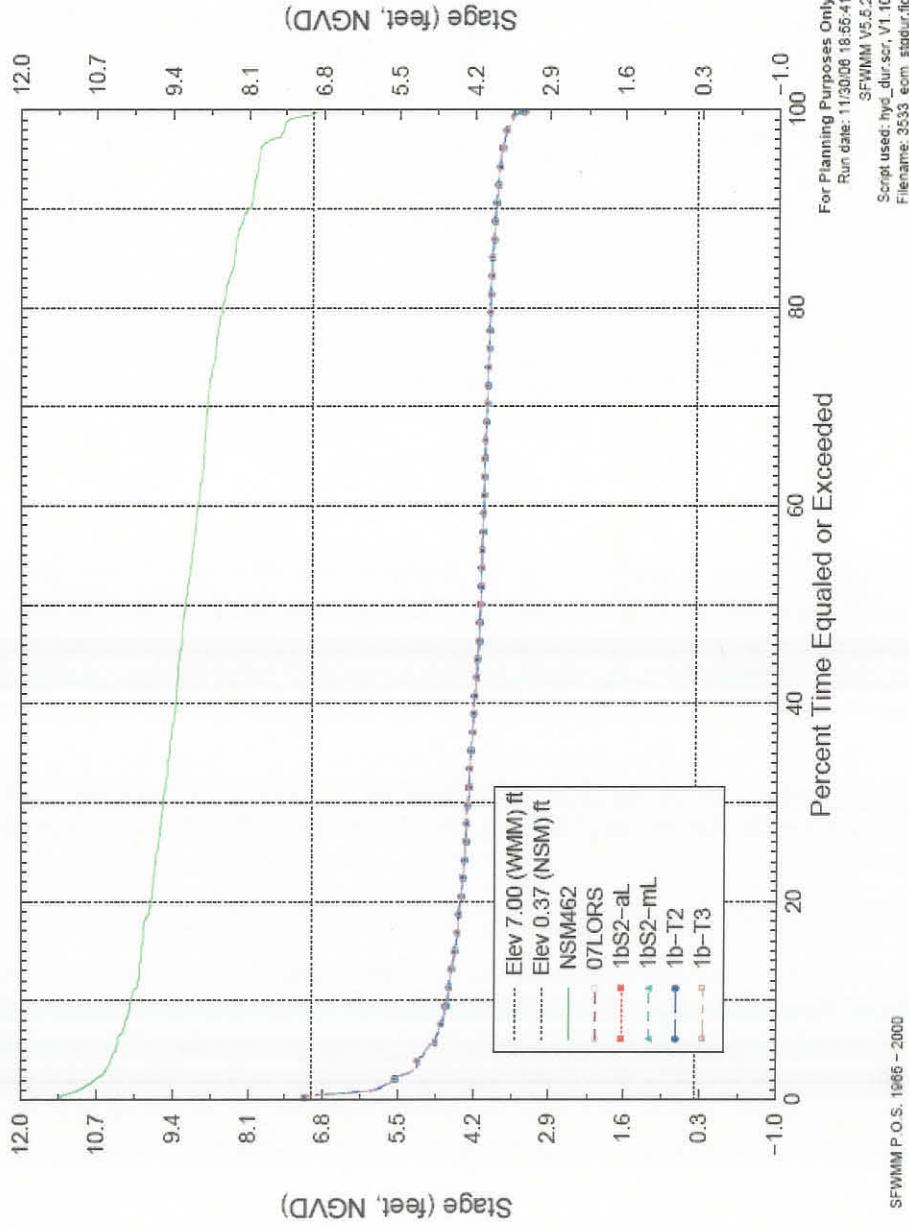


FIGURE C-96: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 35 COLUMN 33 (1)

End of Month Stage Duration Curves for Cell Row 35 Col 33 in the LEC

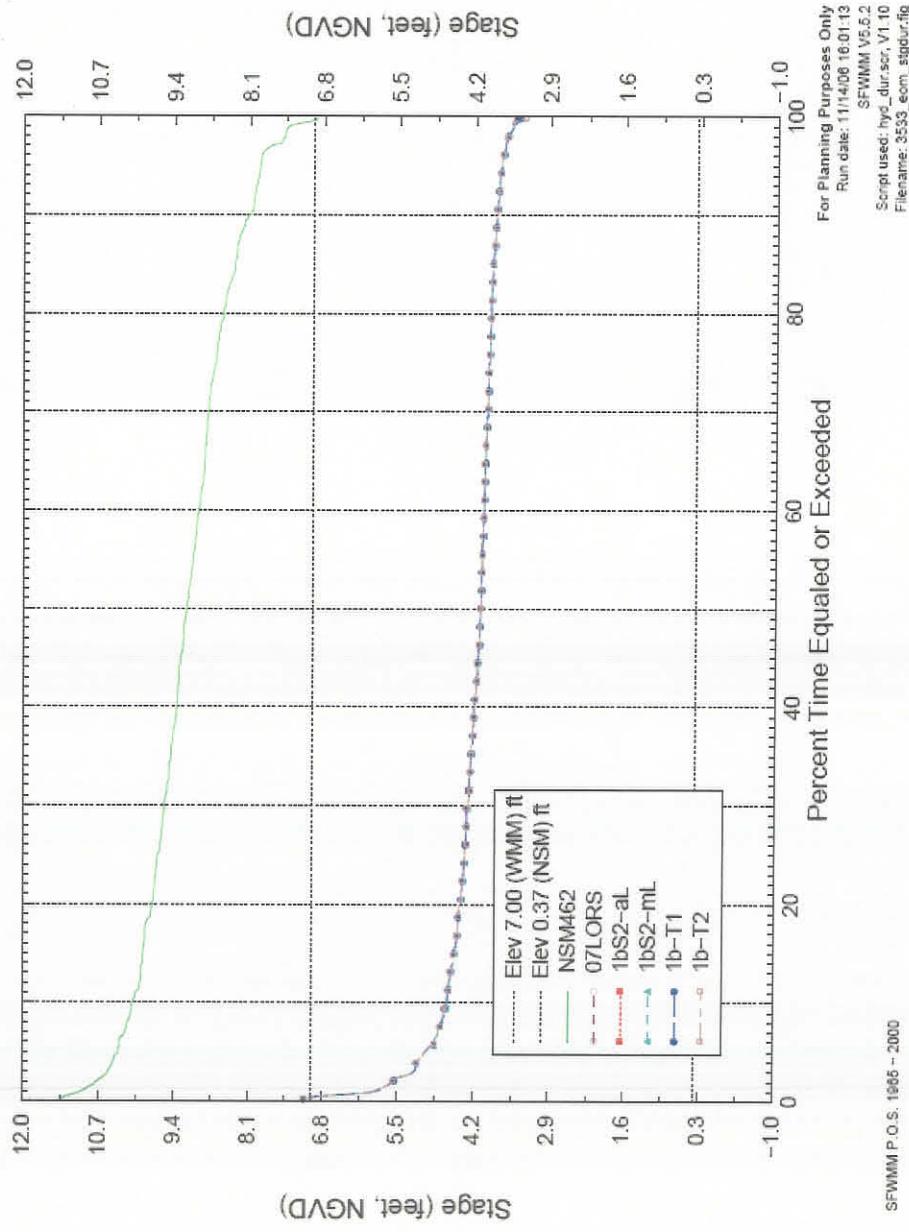


FIGURE C-97: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 35 COLUMN 33 (2)

End of Month Stage Duration Curves for Cell Row 33 Col 30 in the LEC

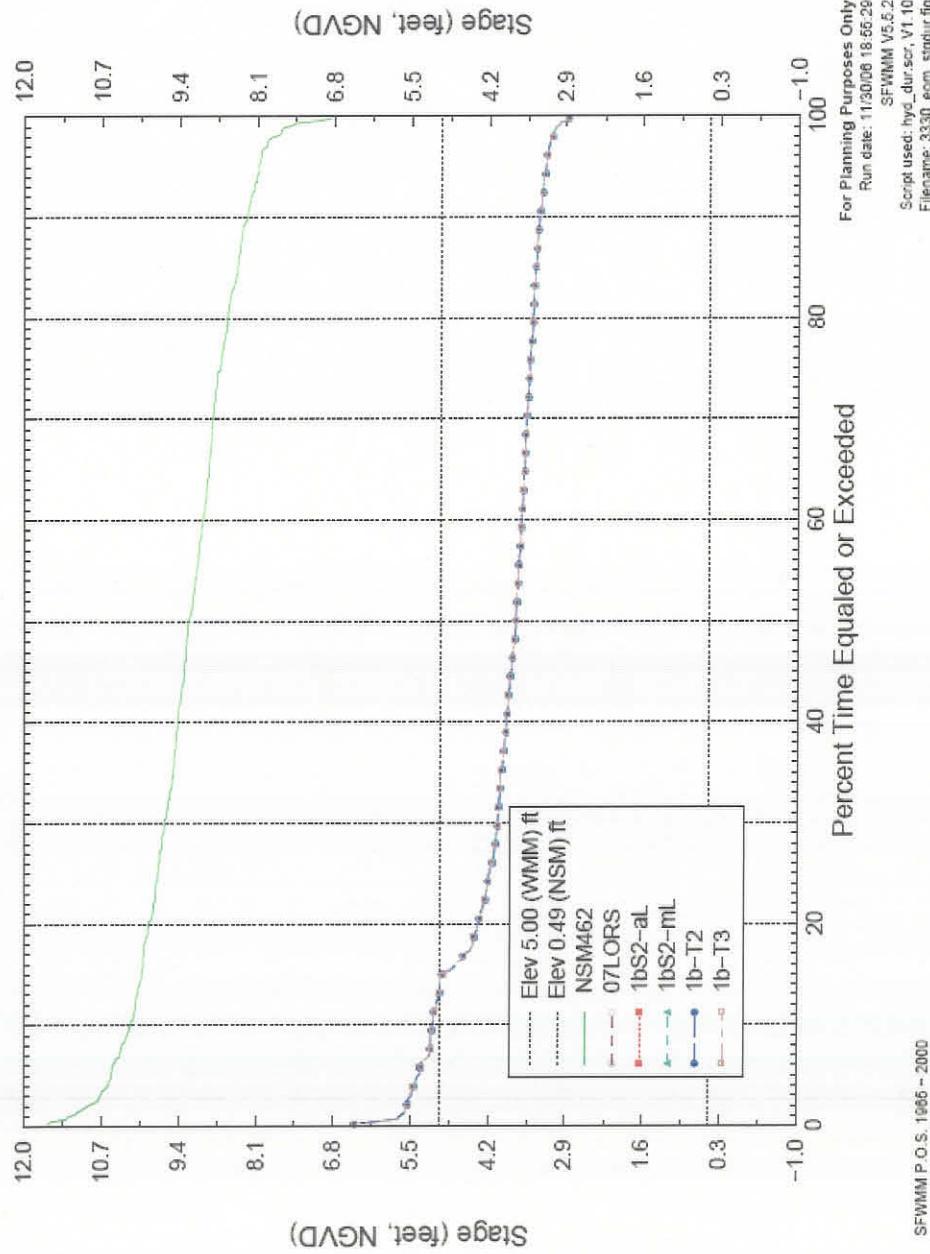


FIGURE C-98: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 33 COLUMN 30 (1)

End of Month Stage Duration Curves for Cell Row 33 Col 30 in the LEC

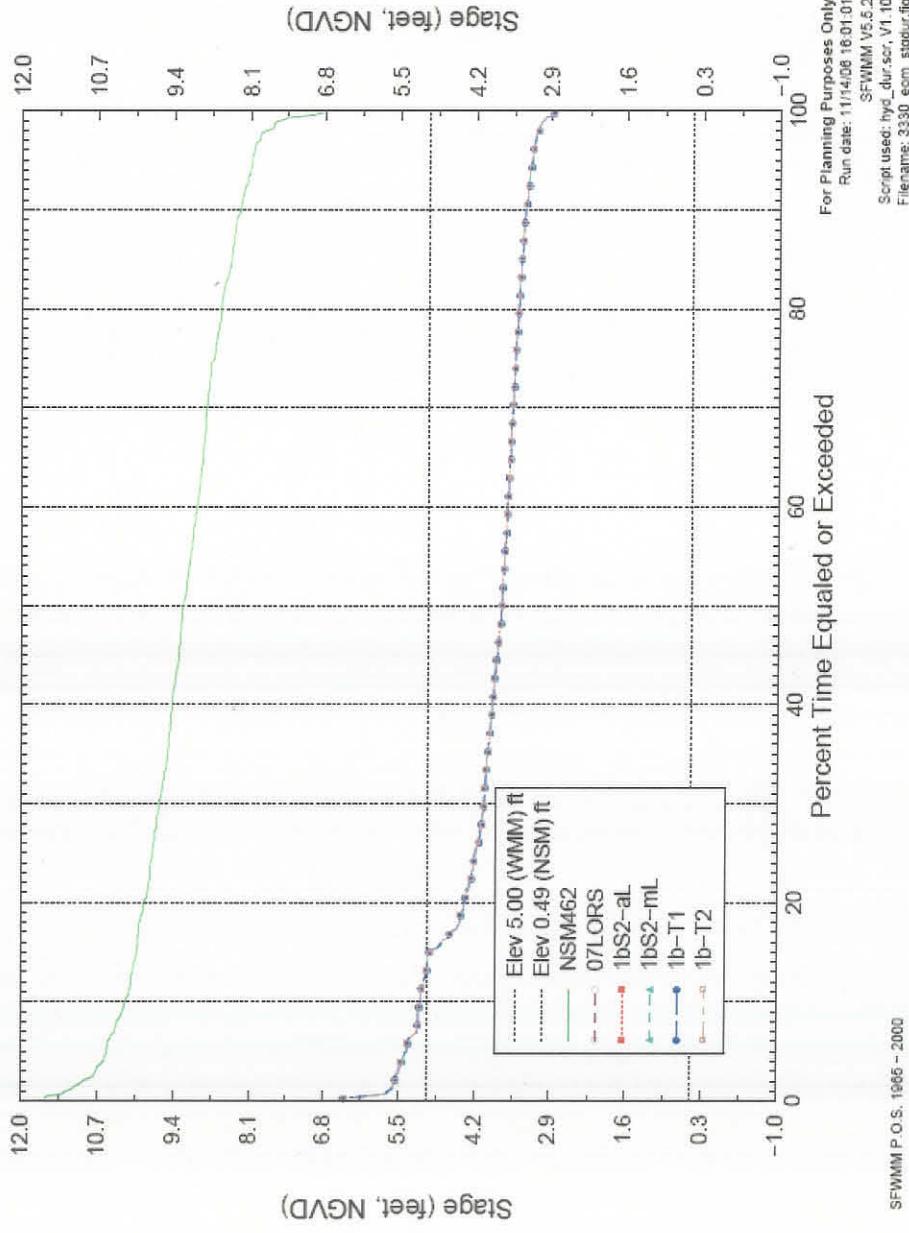


FIGURE C-99: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 33 COLUMN 30 (2)

End of Month Stage Duration Curves for Cell Row 29 Col 31 in the LEC

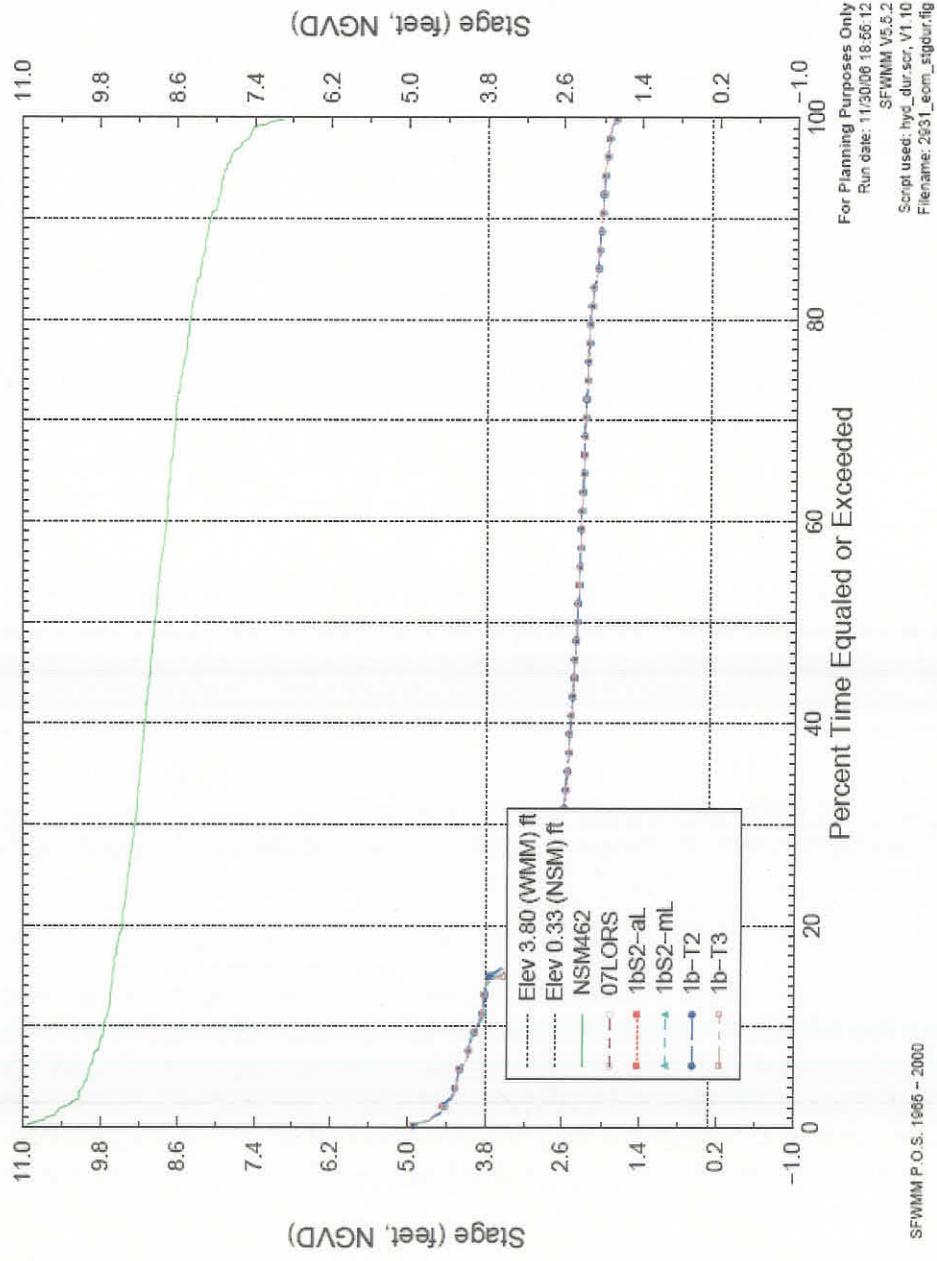


FIGURE C-100: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 29 COLUMN 31 (1)

End of Month Stage Duration Curves for Cell Row 29 Col 31 in the LEC

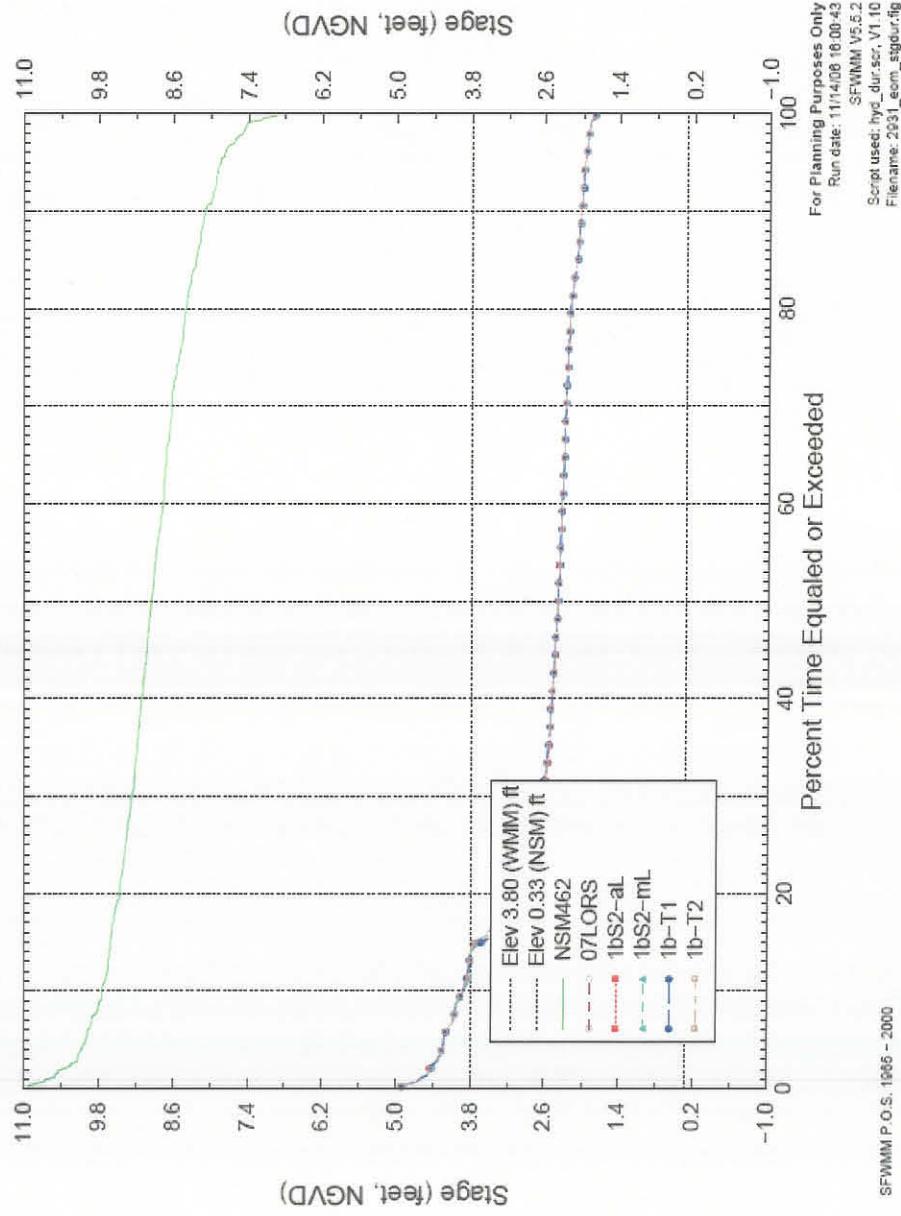


FIGURE C-101: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 29 COLUMN 31 (2)

End of Month Stage Duration Curves for Cell Row 25 Col 29 in the LEC

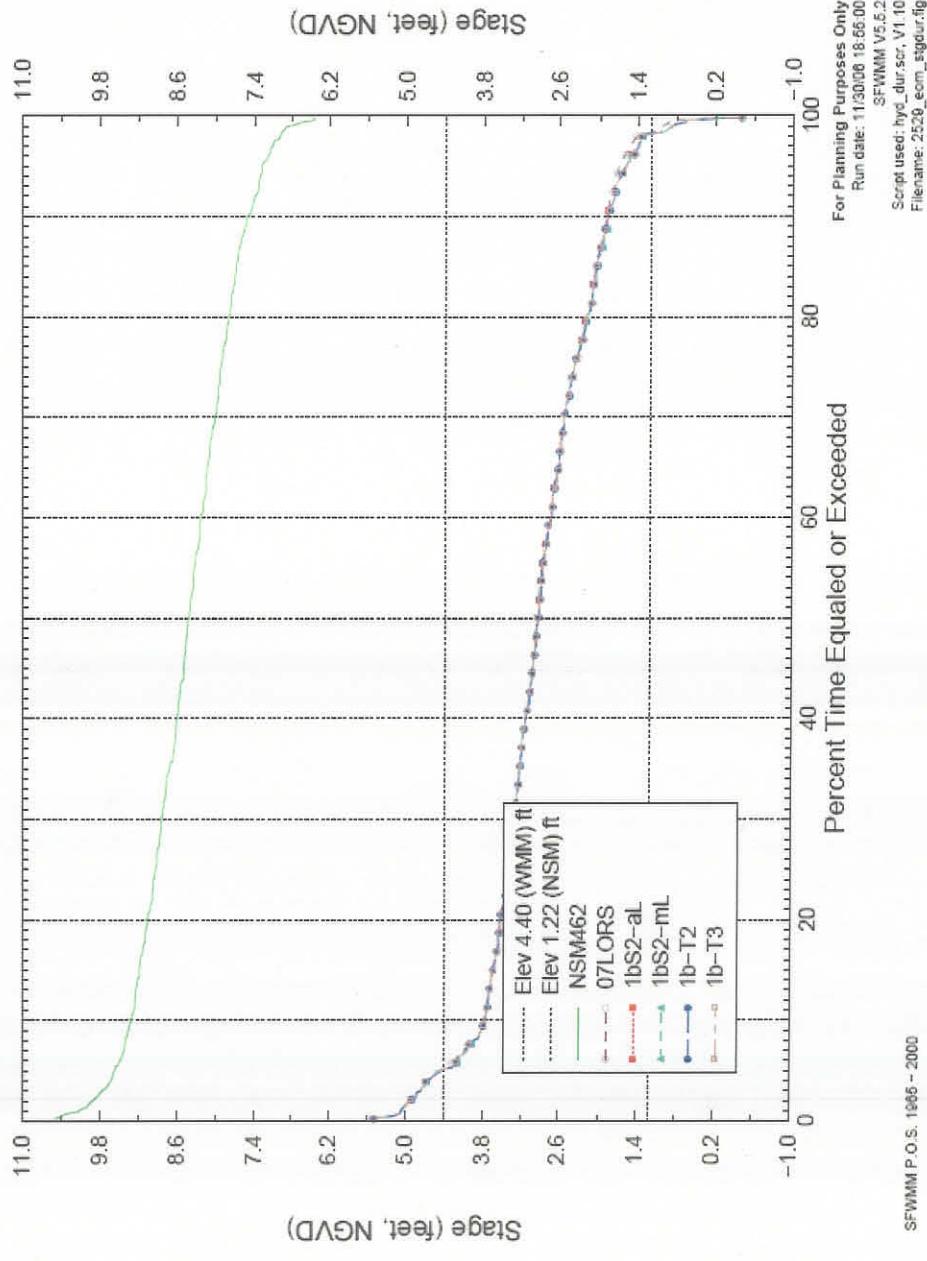


FIGURE C-102: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 25 COLUMN 29 (1)

End of Month Stage Duration Curves for Cell Row 25 Col 29 in the LEC

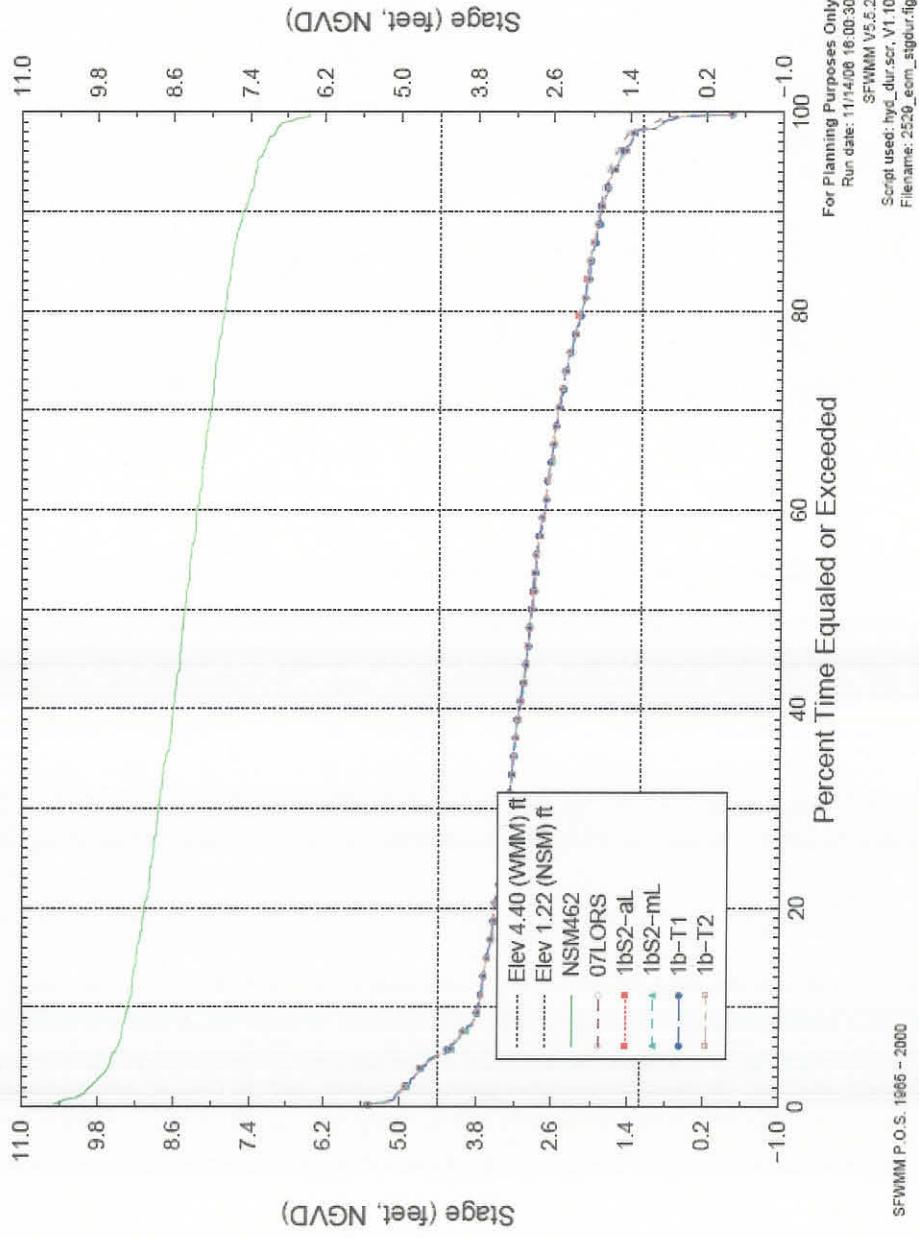


FIGURE C-103: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 25 COLUMN 29 (2)

End of Month Stage Duration Curves for Cell Row 20 Col 28 in the LEC

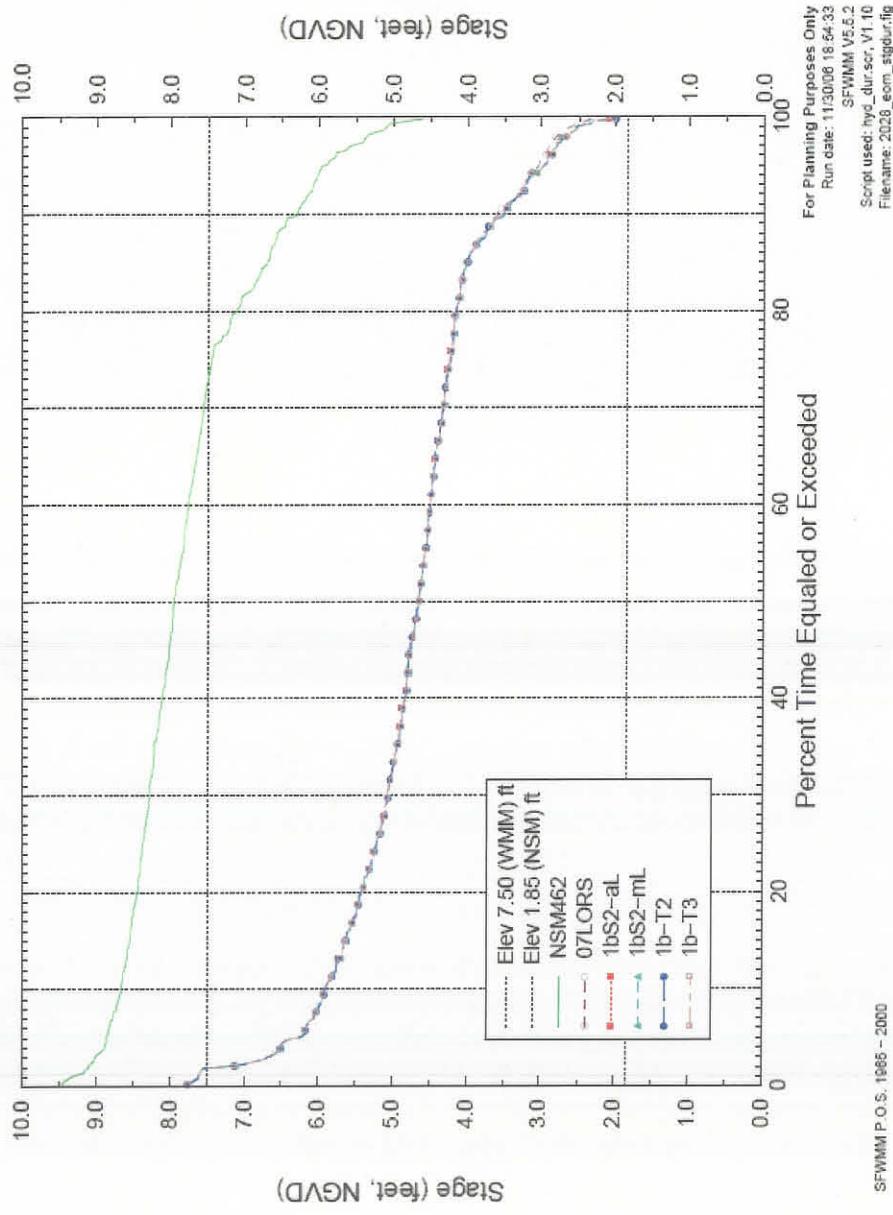


FIGURE C-104: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 20 COLUMN 28 (1)

End of Month Stage Duration Curves for Cell Row 20 Col 28 in the LEC

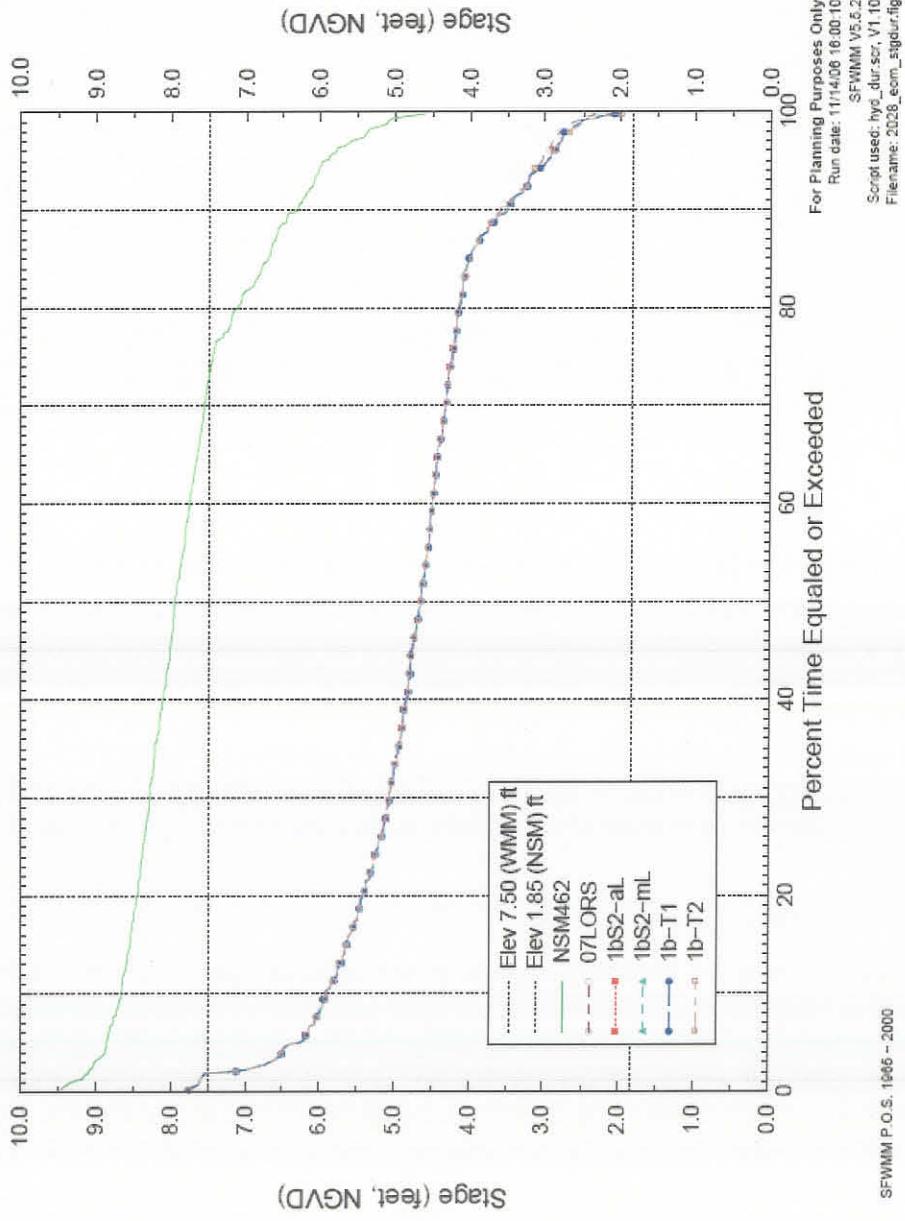


FIGURE C-105: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 20 COLUMN 28 (2)

End of Month Stage Duration Curves for Cell Row 17 Col 27 in the LEC

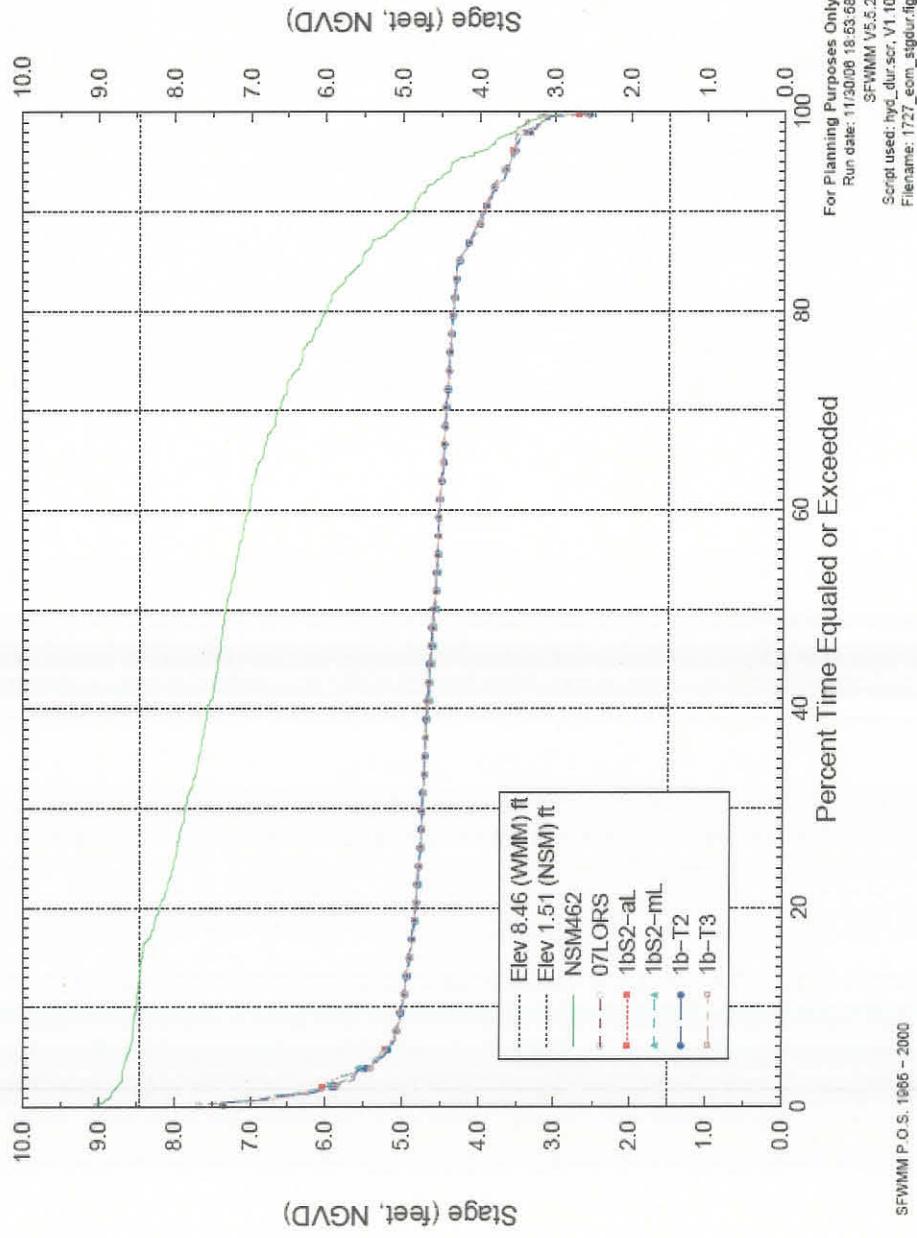


FIGURE C-106: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 17 COLUMN 27 (1)

End of Month Stage Duration Curves for Cell Row 17 Col 27 in the LEC

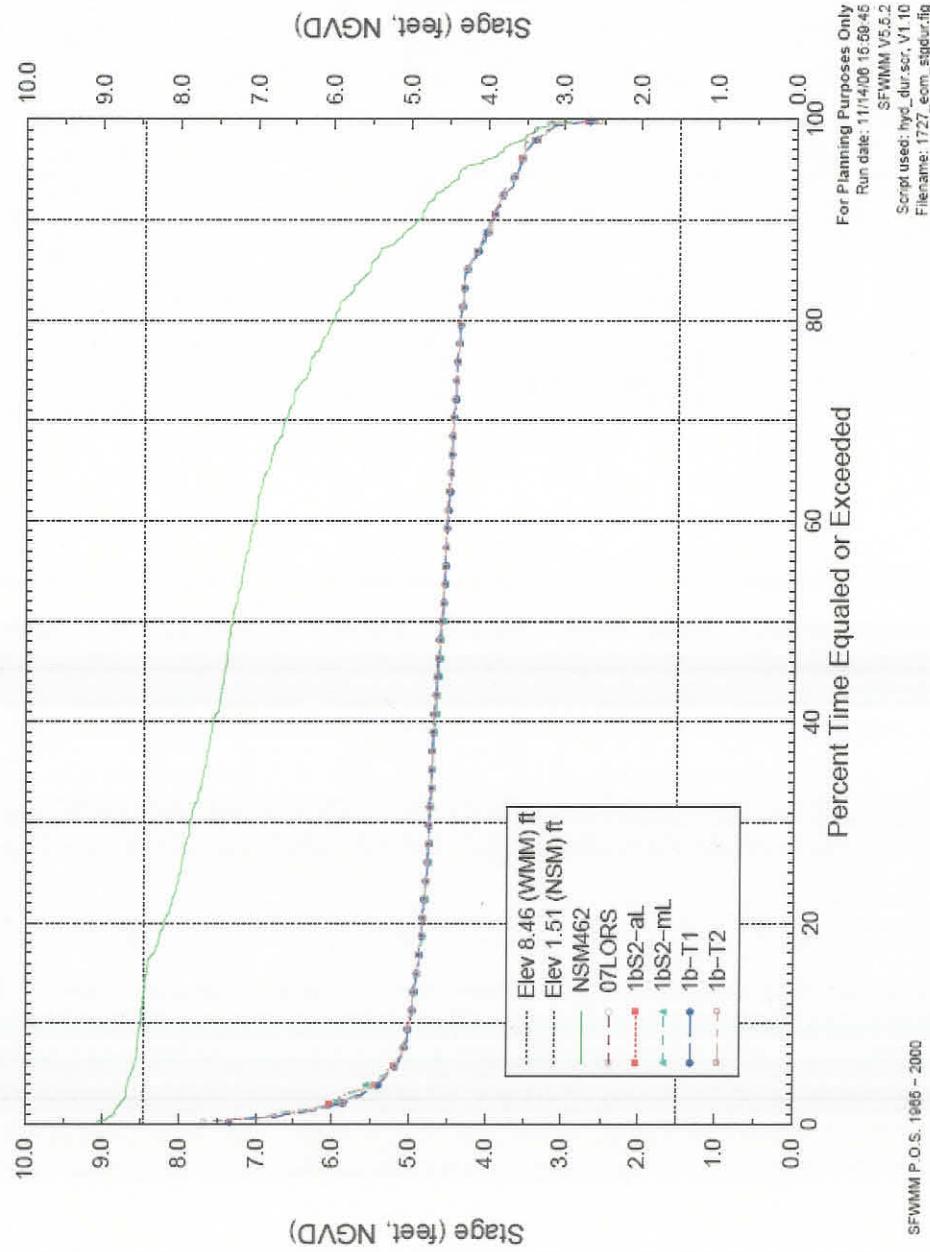


FIGURE C-107: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 17 COLUMN 27 (2)

End of Month Stage Duration Curves for Cell Row 13 Col 25 in the LEC

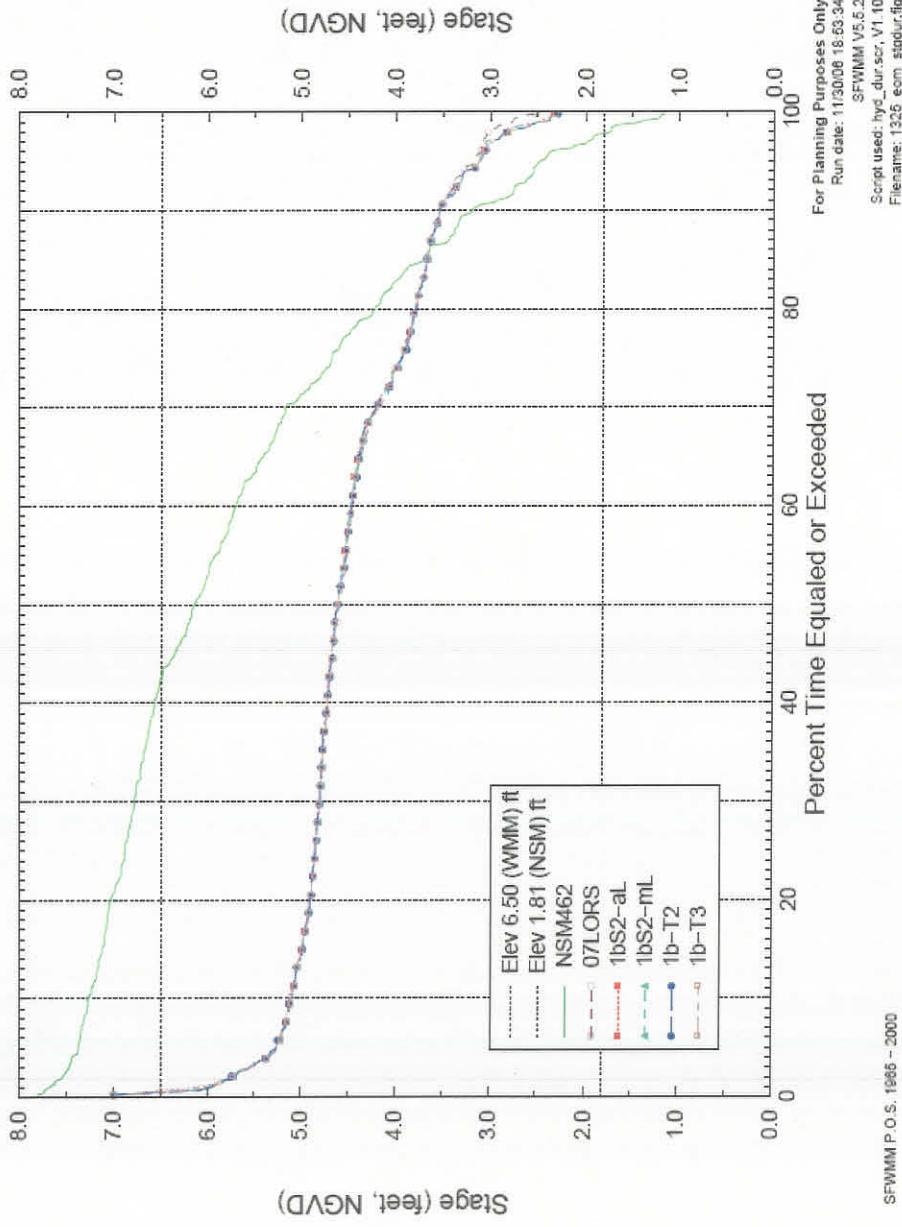


FIGURE C-108: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 13 COLUMN 25 (1)

End of Month Stage Duration Curves for Cell Row 13 Col 25 in the LEC

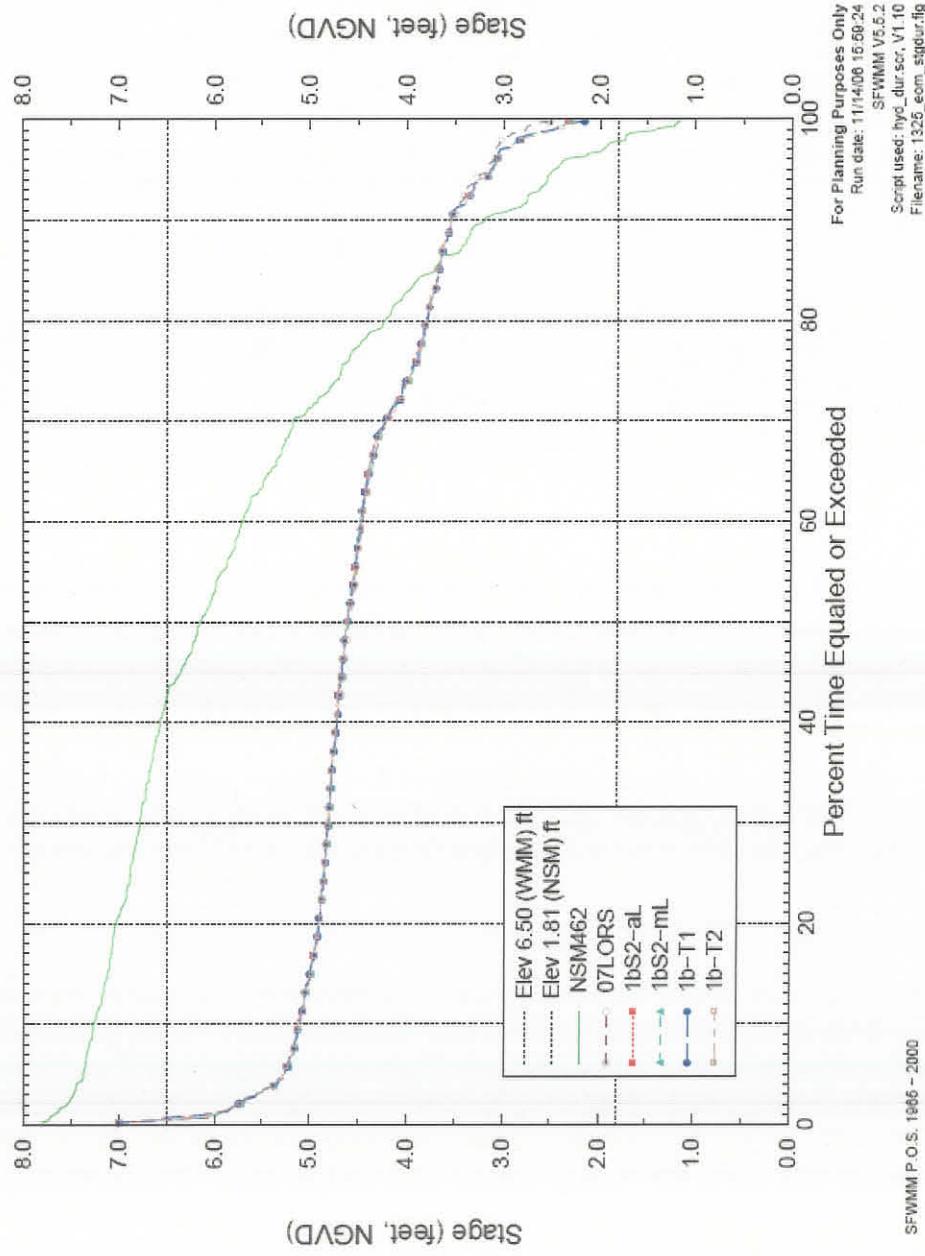


FIGURE C-109: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 13 COLUMN 25 (2)

End of Month Stage Duration Curves for Cell Row 10 Col 25 in the LEC

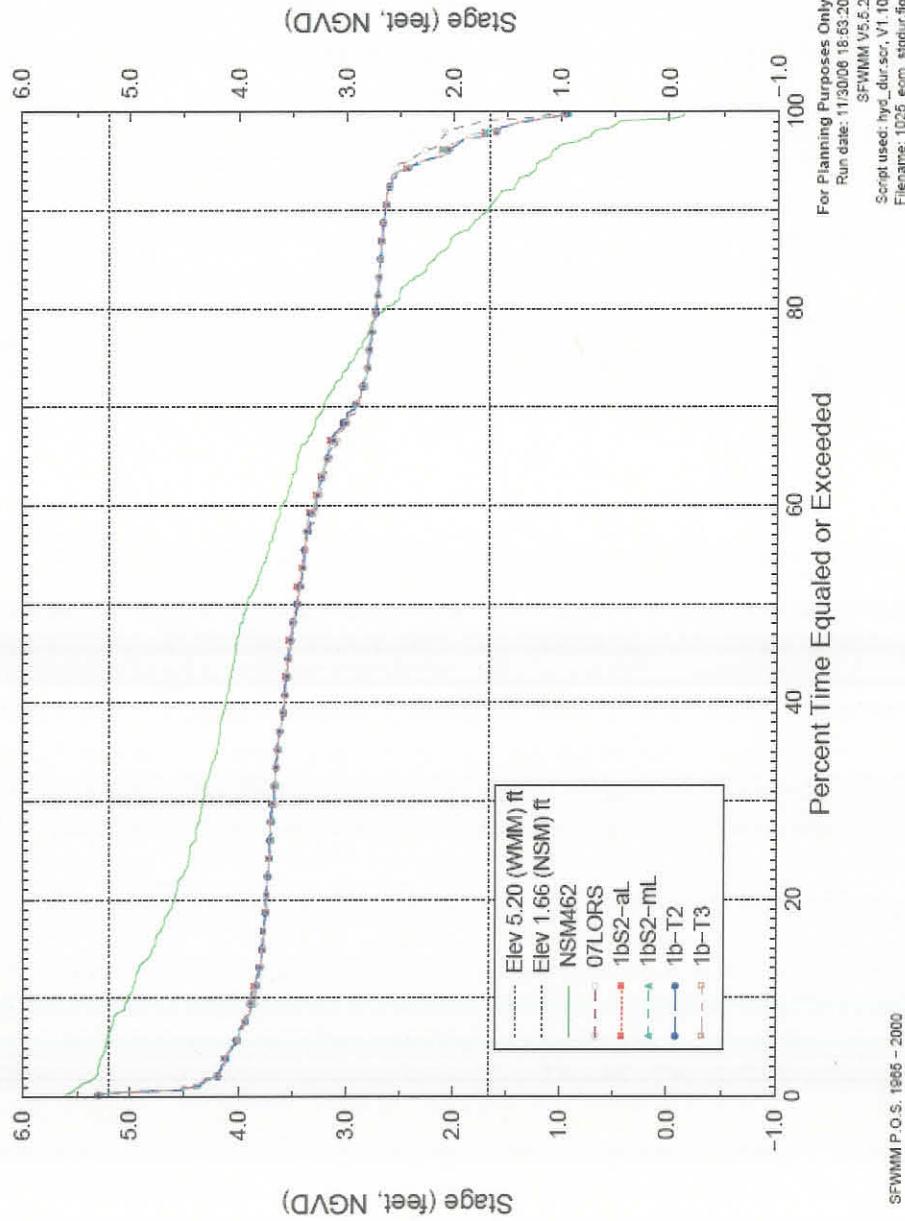


FIGURE C-110: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 10 COLUMN 25 (1)

End of Month Stage Duration Curves for Cell Row 10 Col 25 in the LEC

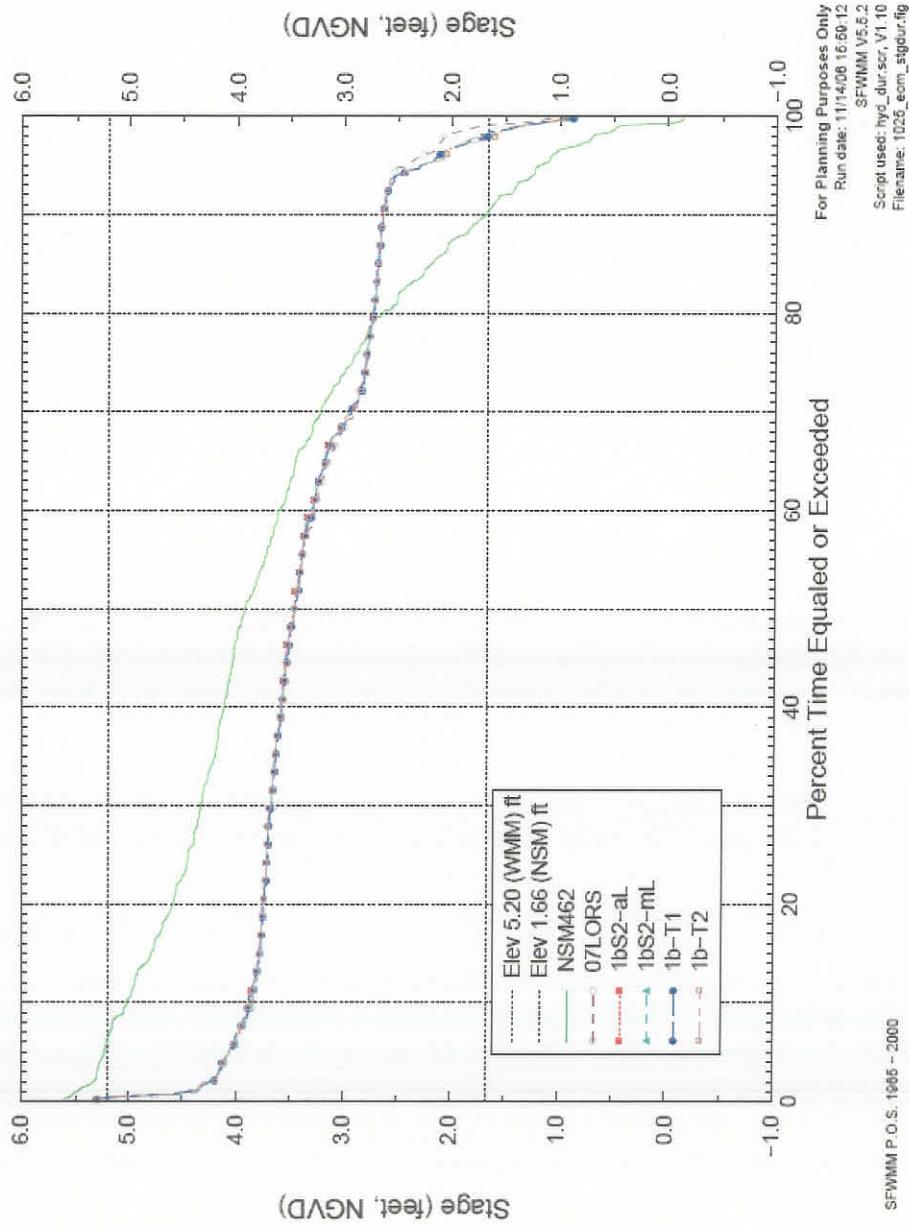


FIGURE C-111: STAGE DURATION CURVES FOR LOWER EAST COAST GRID CELL, ROW 10 COLUMN 25 (2)

Set 1: Initial stages on 01-Jan-2001 pick up where LORSS SFWMM simulations ended (07LORS=12.04', TSP3=10.53'); Represents a continuation of the 36yr simulations to 41yrs.

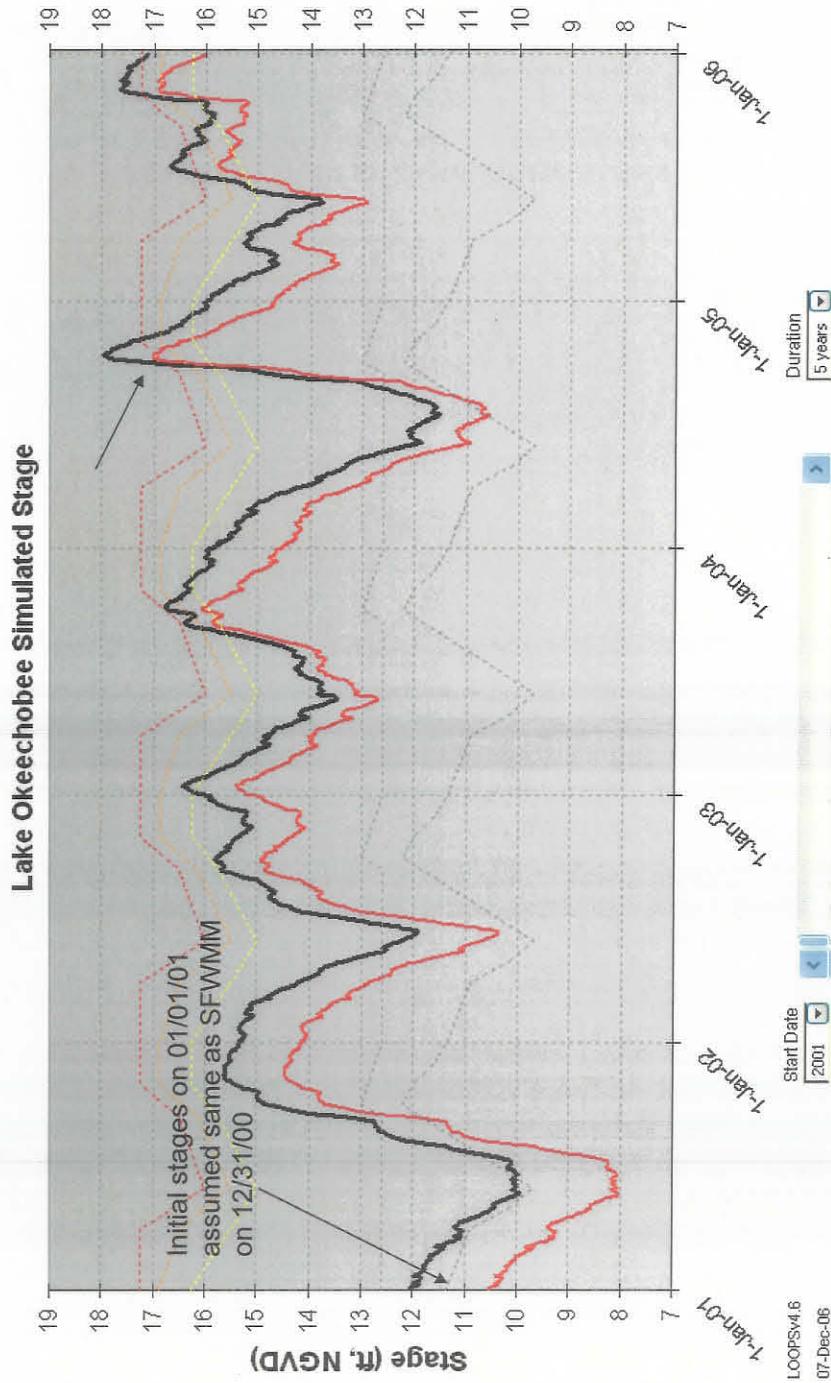


FIGURE C-112: 2001-2005 LAKE OKEECHOBEE SIMULATED STAGE HYDROGRAPH FROM LAKE OKEECHOBEE OPERATIONS SCREENING MODEL (LOOPS), ASSUMING INITIAL STAGE FROM SFWMM

Set 2: Initial stages on 01-Jan-2001 assumed same as historical (07LORS = TSP3 = 11.11')
 Represents what-if the TSP-3 were implemented on 01-Jan-2001.

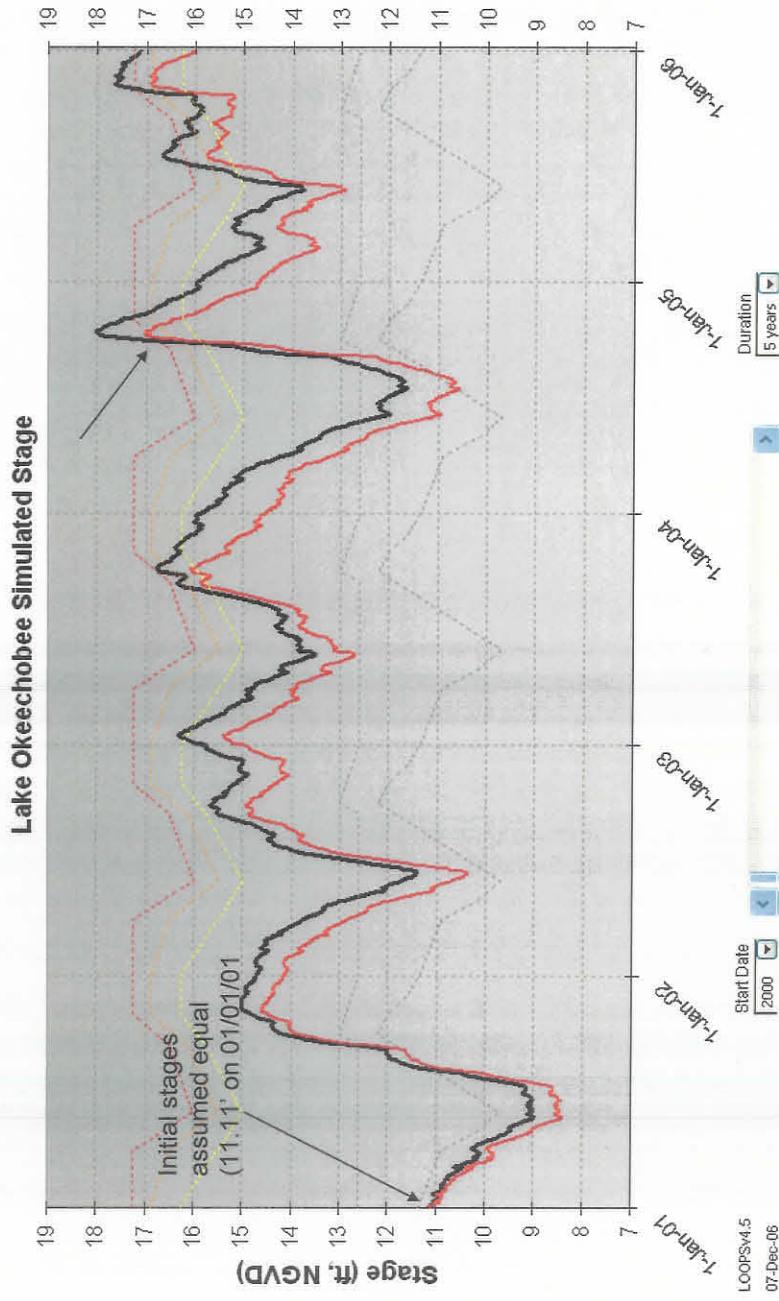


FIGURE C-113: 2001-2005 LAKE OKEECHOBEE SIMULATED STAGE HYDROGRAPH FROM LAKE OKEECHOBEE OPERATIONS SCREENING MODEL (LOOPS), ASSUMING INITIAL STAGE TO MATCH HISTORICAL STAGE

ATTACHMENT D
Selected Performance Measures and Indicators: 2006 LORSS SEIS

SIMULATION RESULTS

An enormous amount of output is generated from each SFWMM simulation and post-processed Performance Measures and Indicators. Selected graphical summaries of the performance of each of the 2006 LORSS SEIS alternatives evaluated are presented and discussed in this attachment. The complete set of performance measure output for all alternatives evaluated under this study is available on the USACE web page for LORS Modeling, at the following web address: <http://hpm.sfrestore.org/loweb/sfwmm/>. Simulation results for the 2006 LORSS SEIS alternatives are available under the informational runs link on this page. The alternative overviews provided in this section have not been modified from the appendix presented within the 2006 LORSS SEIS draft report; requests for additional information from public comments to the 2006 LORSS SEIS draft report have been incorporated into the presentation of the 2007 LORSS SEIS alternatives, where applicable.

The best hydrologic performance measures are those which provide a quantitative indication of how well (or poorly) an alternative meets a specific objective. These hydrologic performance measures are useful surrogates for ecosystem benefits and impacts. Although not presented herein, further evaluations of the results from water quality, ecological, and economic perspectives will be performed as part of the LORSS. Because it was not possible to include all seven alternatives (plus the No Action Alternative) into one graphical plot, three plots having the same performance measures are generated to show the appropriate comparisons. Simulation results for all alternatives, compared to the No Action Alternative, are summarized for the following regions: Lake Okeechobee, Estuaries and Bays (includes Caloosahatchee and St. Lucie estuaries), WCAs and ENP Flows, and Water Supply. Table D-1 summarizes the naming convention used to display the performance measures for each alternative, as names are limited to six to eight characters.

TABLE D-1: PERFORMANCE MEASURE LABELS FOR ALTERNATIVES

Alternative	PM data label
no action alternative	07LORS
LORS-FWO alternative	lors-fwo
alternative 1bS2-A17.25	a1bS2-A
alternative 1bS2-m	a1bS2-m
alternative 2a-B	alt2a-B
alternative 2a-m	alt2a-m
alternative 3-B	alt3-B
alternative 4-A17.25	alt4-A

Lake Okeechobee

A review of the simulation output for Lake Okeechobee requires consideration of a wide range of performance metrics including flood protection, lake ecology, and navigation. Figures D-1 through D-8 are examples of the modeling results as related to the following discussion. All of the figures can be reviewed at: <http://hpm.saj.usace.army.mil/loweb/sfwmm>.

A. Regulatory Releases

An overview of the trends of alternative performance is captured from a review of the performance measure showing average annual flood control releases from Lake Okeechobee and the associated distribution to tidewater through the L-8 canal, the SLE through S-308, the Caloosahatchee Estuary through S-77, and south to the WCAs through S-351 (to the Hillsborough and North New River Canals) and S-354 (to the Miami River Canal), which are shown in Figures D-1 through D-3. Ranking the alternatives with respect to average annual flood control discharge to the SLE, the following trend is observed (highest to lowest): Alternative 2a-m; Alternative 2a-B; Alternative 4-A17.25; Alternative 3-B; No Action Alternative (labeled as 07LORS in all performance measure graphics); LORS-FWO and Alternative 1bS2-m; and lastly Alternative 1bS2-A17.25. Ranking the alternatives with respect to average annual flood control discharge to the Caloosahatchee Estuary, the following trend is observed (highest to lowest): Alternative 2a-m; Alternative 4-A17.25; Alternative 2a-B; Alternative 1bS2-m; Alternative 1bS2-A17.25; No Action Alternative; LORS-FWO; and lastly Alternative 3-B. Generally, the alternatives that most significantly lower the lake stages result in the most significant increase in discharge volume to the estuaries. This point is emphasized by the assumption of the treatment capacity constraint for STA-3/4, which is utilized to limit the average annual volume of lake regulatory releases passed south to STA-3/4 from S-351 and S-354 to a comparable volume for the no action condition and all evaluated LORSS Alternatives. Potential changes in flows to the estuaries will be later discussed in this section.

B. Stage Duration Curves: Flood Protection and Navigation

The stage duration curve for Lake Okeechobee is a key indicator of relative alternative performance (Figures D-4 through D-6). Two alternatives, LORS-FWO and Alternative 3-B, demonstrate a trend to reduce lake stages by approximately 0.1 to 0.5 feet compared to the current WSE regulation schedule (the No Action Alternative). Three alternatives, Alternative 1bS2-A17.25, Alternative 1bS2-m, and Alternative 4-A17.25, demonstrate a trend to reduce lake stages by approximately 1.0 to 1.2 feet. Two alternatives, Alternative 2a-B and Alternative 2a-m, demonstrate a trend to reduce lake stage by greater than 1.2 feet, up to approximately 1.5 feet. Peak stages for the No Action Alternative and the other alternatives are summarized as follows: 18.50 ft, NGVD for the No Action Alternative; 18.03 ft for Alternative LORS-FWO; 17.48 ft for Alternative 1bS2-A17.25; 17.23 ft for Alternative 1bS2-m; 17.13 ft for Alternative 2a-B; 17.05 ft for Alternative 2a-m; 18.04 ft for Alternative 3-B; and 17.22 ft for Alternative 4-A17.25. Three of the alternatives plus the No Action Alternative show simulated stages above 17.25 ft, NGVD: 331 days for the No Action Alternative; 59 days for LORS-FWO; 12 days for Alternative 1bS2-A17.25; and 107 days for Alternative 3 (note: 13,149 days in the SFWMM 36-year POR). Aviodance of the 17.25 feet elevation offers additional protection for public safety and the HHD. Extreme high lake stages have also been documented to adversely impact the plant and animal communities, through processes which include the following: physical uprooting of emergent and submerged plants; reduced light levels in the water column due to increased suspended sediment; and littoral zone exposure to increased nutrient levels from the water column. The frequency of occurrence for lake stages above 16.0 feet, 16.5 feet, 17.0 feet, and 17.25 feet are summarized in Figure D-7.

Alternatives observed to most significantly reduce the extreme high water stages for Lake Okeechobee (upper ten percent of the stage duration curve) also show the most significant

reduction in lake stages during dry conditions (bottom ten percent of the stage duration curve). Increased frequency of low water conditions can adversely impact the health of the Lake Okeechobee littoral zone through increased susceptibility to fire and drought conditions, habitat loss, expansion of exotic and invasive vegetation, and oxidation of organic soils. The minimum simulated stages for Lake Okeechobee are summarized as follows: 9.61 feet for the No Action Alternative; 9.11 feet for LORS-FWO; 8.88 feet for Alternative 1bS2-A17.25; 8.82 feet for Alternative 1bS2-m; 8.36 feet for Alternative 2a-B; 8.27 feet for Alternative 2a-m; 9.07 feet for Alternative 3-B; and 8.42 feet for Alternative 4-A17.25. Increased frequency of low water conditions may also potentially impact recreational and commercial navigation and availability of lake supply for water supply needs. The number of days below 12.56 feet elevation is stated in the following summary: 2577 days for the No Action Alternative; 3336 days LORS-FWO; 4809 for Alternative 1bS2-A17.25; 4842 days for Alternative 1bS2-m; 5141 days for Alternative 2a-B; 5776 days for Alternative 2a-m; 3260 days for Alternative 3-B; and 4841 days for Alternative 4-A17.25.

C. Lake Okeechobee Ecology: Extreme High Stage, Extreme Low Stage, Stage Envelope

RECOVER is an arm of the CERP responsible for linking science and the tools of science to a set of system-wide planning, evaluation and assessment tasks. The most current (as of March 2006) RECOVER performance measures for Lake Okeechobee: extreme low lake stage, Lake Okeechobee extreme high lake stage, and Lake Okeechobee stage envelope, were utilized to evaluate the alternatives of the LORSS effort. In-depth documentation and rationale for these performance measures is available through the RECOVER performance measure documentation in the draft RECOVER CERP System-wide Performance Measures report (RECOVER, 2006), at the following web address: www.evergladesplan.org/pm/recover/eval_team_perf_measures.cfm. Extreme low and extreme high lake stage are evaluated with response curves. For extreme low lake stage, zero weeks below 10 ft, elevation NGVD responds to a score of 100, and 540 weeks or greater with stages below 10 ft responds to a worst case situation (15 weeks per year over 36 year simulation period), with scores linearly varied between the two extremes. For extreme high lake stage, zero weeks above 17 ft elevation responds to a score of 100 and 396 weeks or greater with stages above 17 weeks responds to the assumed worst case situation (11 weeks per year), with scores linearly varied between the two extremes. The resultant standard scores for extreme low and high lake stage are summarized as follows, with low score followed by high score: 99/83 for the No Action Alternative; 95/90 for LORS-FWO; 87/99 for Alternative 1bS2-A17.25; 87/99 for Alternative 1bS2-m; 83/100 (rounded up) for Alternative 2a-B; 78/100 (rounded up) for Alternative 2a-m; 92/85 for Alternative 3-B; and 85/99 for Alternative 4-A17.25.

The stage envelope performance measure similarly documents the benefits of seasonally-variable water levels within the range of 12.5 feet (June-July low) and 15.5 feet (November-January high) on the plant and animal communities of Lake Okeechobee. The conceptualization of the optimal stage envelope seasonal variation is shown in Figure D-8. The comparison actually utilizes smoothed boundaries for the upper and lower envelope); in simplified terms, penalty points are assigned to each alternative based on deviations outside of the envelope, with increased penalty points with increased distance away from the optimal envelope. The worst case scenario for variability above the stage envelope is assumed to be one where the lake stage hydrograph is always in the poor zone (one foot outside of the stage envelope), which equates to a total score

of 1872 foot-weeks; the response curve is a line between 0 (target, score of 100) and 1872 foot-weeks (score of 0). For deviation of lake stage below the envelope, the target is 192 weeks. This is the score that would be obtained if all years had hydrographs within the optimal zone, except for once per decade the stage falling to just below 11 feet elevation for an average of three months. The response curve is a line between 192 (192 foot-weeks or less receives a score of 100) and 1872 foot-weeks (worst case scenario receives a score of zero). The resultant standard scores for lake daily stage (RECOVER performance measure specified weekly stage, but only daily stage comparisons are available within the LORSS evaluation timeframe) above and below the stage envelope are summarized as follows, with the above score followed by the below score: 75/56 for the No Action Alternative; 63/62 for LORS-FWO; 34/80 for Alternative 1bS2-A17.25; 33/82 for Alternative 1bS2-m; 24/90 for Alternative 2a-B; 9/94 for Alternative 2a-m; 60/53 for Alternative 3-B; and 28/86 for Alternative 4-A17.25. The percentage of time within the stage envelope was also identified for all alternatives as comparable, ranging within a narrow band from 25 percent (Alternative 3) to 32 percent (Alternative 2a-B) of the 36-yearPOR. Given the similarity of time within the stage envelope band, additional focus was placed on the deviation of stages when outside the stage envelope band; alternatives observed to most significantly reduce the extreme high water stages for the lake will score better for the stage envelope above and tend to score lower for the stage envelope below.

Estuaries and Bays

One of the objectives for managing Lake Okeechobee levels was to reduce the number of high regulatory discharges to the Caloosahatchee and St. Lucie estuaries. Recognizing the need to lower the high lake levels, a strategy was incorporated into the alternatives to make more low-level (environmentally friendly) releases to avoid the high-level regulatory releases. Figures D-9 through D-23 are examples of the modeling results as related to the following discussion. All of the figures can be reviewed at: <http://hpm.saj.usace.army.mil/loweb/sfwm>.

A. Caloosahatchee Estuary

For all the alternatives, the mean monthly flows between 2800 and 4500 cfs were essentially the same or decreased. For mean monthly flows greater than 4500 cfs, only two alternatives had the same or less events: LORS-FWO and Alternative 3-B. The rest of the alternatives had an increase of two to three events of high flow with the exception of Alternative 2a-B which had an increase of seven events of high flow. The base condition and all alternatives were about five times greater than the target for high flows.

In addition to the number of mean monthly flows, the duration of high-flow releases (consecutive months of >4500 cfs) are of concern. All of the alternatives showed significant differences in the duration of mean monthly high-flow events. A discussion of the longest duration of the total estuary high-flow will be presented in this attachment. The worst case for No Action Alternative (base run) was 24 periods of two to three months duration of high-flow. The worst case for LORS-FWO was 23 periods of two to three months duration of high-flow. The worst case for Alternative 1bS2-A17.25 was seven periods of six to seven months duration of high-flow. The worst case for Alternative 1bS2-m was four periods of four to five months duration of high-flow. The worst case for Alternative 2a-B was seven periods of six to seven

months duration of high-flow. The worst case for Alternative 2a-m was four periods of four to five months duration of high-flow. The worst case for Alternative 3-B was seven periods of six to seven months duration of high-flow. The worst case for Alternative 4-A17.25 was seven periods of six to seven months duration of high-flow.

For the mean monthly flows less than 300 cfs, all the alternatives significantly reduced the number of events (by almost half the number). Alternative 2a-B, Alternative 2a-m and Alternative 4-A17.25 showed the least improvement.

B. St. Lucie Estuary

For all the alternatives, the mean monthly flows between 2000 and 3000 cfs were nearly the same or decreased. For mean monthly flows greater than 3000 cfs, the alternatives had mixed results. For LORS-FWO, Alternative 1bS2-A17.25, Alternative 1bS2-m, Alternative 3-B, and Alternative 4-A17.25 there was a slight reduction of high-flow events. Only Alternative 2a-B and Alternative 2a-m had a greater number of flow events greater than 3000 cfs. The base condition and all alternatives were two to three times greater than the target for high flows.

In addition to the number of mean monthly flows, the duration of high-flow releases (consecutive months of >3000 cfs) are of concern. All of the alternatives showed differences in the duration of mean monthly high-flow events. A discussion of the longest duration of the total estuary high-flow will be presented in this attachment. The worst case for No Action Alternative (base run) was six periods of six to seven months duration of high-flow. The worst case for LORS-FWO was nine periods of four to five months duration of high-flow. The worst case for Alternative 1bs2-A17.25 was eight periods of four to five months duration of high-flow. The worst case for Alternative 1bS2-m was seven periods of six to seven months duration of high-flow. The worst case for Alternative 2a-B was seven periods of six to seven months duration of high-flow. The worst case for Alternative 2-m was seven periods of six to seven months duration of high-flow. The worst case for Alternative 3-B was seven periods of six to seven months duration of high-flow. The worst case for Alternative 4-A17.25 was eight periods of four to five months duration of high-flow.

For the mean monthly flows less than 350 cfs, the minimum flow needs were generally thought to be met by intervening flows (including groundwater flows). With regard to releases from S-80, most alternatives had essentially the same number of low-flow months as the base case. There were three notable differences: Alternative 2a-B and Alternative 3-B had more low-flow months while Alternative 2a-m had fewer low-flow events.

C. Lake Worth Lagoon

For all the alternatives, the number of times the two-day moving average flow was greater than 1000 cfs decreased. The number of times the seven-day moving average flow was greater than 500 cfs were nearly the same except for slight increase in LORS-FWO, Alternative 2a-B and Alternative 2a-m. The number of times the seven-day moving average flow was equal to zero remained unchanged for all alternatives.

D. Biscayne Bay

Flows to Biscayne Bays were essentially unchanged (+ 1 to 2 kAF/yr) in all the alternatives.

E. Whitewater Bay

For most alternatives, there was less than a 3 kAF/yr reduction in overland flow. However, Alternative 4-A17.25 and Alternative 2a-m had a 4 and 5 kAF/yr reduction in overland flow, respectively.

F. Florida Bay

Flows to Biscayne Bays were essentially unchanged (+ 1 kAF/yr at most) in all the alternatives.

WCA and ENP Flows

The flow changes, as related to the various alternatives, in the WCAs and ENP are discussed in this section. Generally, the flow changes (as indicated by the transect flows) in these areas are relatively small. As a result of greater-than-normal lake mixing from recent hurricanes, the STA-3/4 flow constraint of approximately 63,000 acre-feet/yr reduces the amount of flow from Lake Okeechobee that normally goes directly to WCA 3A; this is because of the increased loading that could occur due to an increased suspension of nutrients in Lake Okeechobee. The STA-3/4 flow constraint is included in all the alternatives as well as in the No Action Alternative base condition. Figures D-24 through D-26 are examples of the modeling results as related to the following discussion. All of the figures can be reviewed at:

<http://hpm.saj.usace.army.mil/loweb/sfwmm>.

A. WCA 1

Flows across Transect T1 show little variation (\pm 1 kAF/yr) in all the alternatives.

B. WCA 2A

Flows across Transect T2 show some variation in the alternatives. Alternative 1bS2-A17.25 and Alternative 1bS2-m show an increase of about 6 kAF/yr; LORS-FWO, Alternative 2a-B and Alternative 3-B show little change (-1 or -2 kAF/yr); and Alternative 2a-m and Alternative 4-A17.25 show a decrease in flow (-5 and -6 kAF/yr).

C. WCA 3A

Flows across central WCA 3A (Transects T6 and T7) show slight variations between alternatives. Alternatives LORS-FWO, 1bS2-A17.25, 1bS2-m, 2a-B and 3-B show overland flow differences of about \pm 3 kAF/yr. Alternative 2a-m and Alternative 4-A17.25 show decreases of -13 kAF/yr and -7 kAF/yr.

D. ENP

Overland flows into ENP are shown as Transects T17 and T18. LORS-FWO decreases flow (-4 kAF/yr); Alternative 1bS2-A17.25 increases flow (2 kAF/yr); Alternative 1bS2-m shows no change; Alternative 2a-B decreases flow (-6 kAF/yr); Alternative 2a-m decreases flow (-13 kAF/yr); Alternative 3-B decreases flow (-4 kAF/yr); Alternative 4-A17.25 decreases flow (-9 kAF/yr).

Water Supply

All alternatives evaluated, including the No Action Alternative, assume operation of the SFWMD temporary forward pumps for water supply at S-354 (400 cfs), S-351 (600 cfs), and S-352 (400 cfs). Based on preliminary operational guidance from the SFWMD, the pumps are simulated to trigger on for water supply demands if Lake Okeechobee stage falls below 10.2 feet; the pumps are assumed triggered off when Lake Okeechobee stage recovers to 11.2 feet. The No Action Alternative assumes the existing SSM line (set by the SFWMD) to be in place. Based on guidance from the SFWMD, a modified SSM line and operations are anticipated to be implemented in advance of any new regulation schedule resultant from LORSS; all alternatives, therefore, assume a one foot lowering of the existing SSM line as a surrogate for the anticipated SSM changes by the SFWMD (this assumption is based on a recommendation from the SFWMD). The No Action Alternative is the only alternative to utilize the existing SSM line. In order to provide additional data related to the assumed lowering of the SSM line, a sensitivity model run was completed for the Preferred Alternative with the SSM line returned to the existing (same as the No Action Alternative) level.

Three performance measures are presented to compare the potential water supply impacts of the alternatives. Particular emphasis is given to water supply impacts under the most significant drought conditions experienced within the simulation POR, as water supply needs under drought conditions are highly susceptible given the observed lowering of Lake Okeechobee stages under the alternatives. Figures D-27 through D-32 are examples of the modeling results as related to the following discussion. All of the figures can be reviewed at:

<http://hpm.saj.usace.army.mil/loweb/sfwmm>.

A. Everglades Agricultural Area

Simulated water supply effects to the EAA are shown based on the performance measure for mean annual EAA Supplemental Irrigation, demands and demands not met. The alternatives are ranked in order of the mean annual volume of demands not met during the drought years of 1971, 1975, 1981, 1985, and 1989, with increased demand not met indicative of higher potential impacts to EAA water supply: 27,000 acre-feet of demand not met for LORS-FWO (6% of total demand is not met); 37,000 acre-feet for Alternative 3-B (8% not met); 44,000 acre-feet for the No Action Alternative (10% not met); 67,000 acre-feet for Alternative 1bS2-A17.25 (15% not met); 73,000 acre-feet for Alternative 1bS2-m (16% not met); 84,000 acre-feet for Alternative 4_A17.25 (18% not met); 103,000 acre-feet for Alternative 2a-B (22% not met); and the highest of 134,000 acre-feet for Alternative 2a-m (27% not met).

B. Lake Okeechobee Service Area

Simulated water supply effects to the LOSA are shown based on the performance measure for mean annual LOSA Supplemental Irrigation, demands and demands not met. The alternatives are ranked in order of the mean annual volume of demands not met during the drought years of 1971, 1975, 1981, 1985, and 1989, with increased demands not met indicative of higher potential impacts to LOSA water supply: 15,000 acre-feet of demand not met for LORS-FWO (5% of total demand is not met); 18,000 acre-feet for Alternative 3-B (5% not met); 24,000 acre-feet for the No Action Alternative (7% not met); 28,000 acre-feet for Alternative 1bS2-A17.25 (8% not met); 30,000 acre-feet for Alternative 1bS2-m (9% not met); 39,000 acre-feet for Alternative 4-A17.25 (11% not met); 45,000 acre-feet for Alternative 2a-B (13% not met); and the highest of 56,000 acre-feet for Alternative 2a-m (17% not met).

C. Lower East Coast

Simulated water supply effects to the Lower East Coast are shown based on the number of months of water supply cutbacks for the 36-year POR. The performance measure graphics selected show the number of months under cutback (all cutbacks are phase 1 cutbacks for the LORSS Alternatives) for each of the following LECSA: Northern Palm Beach County, LECSA1, LECSA2, and LECSA3. Phase 1 cutbacks can be induced by one of three triggers: Lake stage in SSM Zone (indicated by upper label on figures D-30 through D-32), local trigger well stages (lower data label; as expected, this changes minimally for the regulation schedule alternatives), or dry season criteria (indicated by the middle data label; phase 1 restrictions remain in place until the end of the dry season if water restrictions from the Lake or local groundwater triggers occurred anytime during the dry season). For LECSA Northern Palm Beach County, the No Action Alternative shows 31 months of simulated cutbacks; slight increases to 33 months are observed in the simulation results for Alternative 1bS2-A17.25, Alternative 1bS2-m, Alternative 2a-B, Alternative 2a-m, and Alternative 4-A17.25; significant reduction of cutback months are observed with 16 months under cutback for the LORS-FWO alternative and Alternative 3-B. The same trend is observed in the simulation results for LECSA1, LECSA2, and LECSA3. The No Action Alternative simulation results show 31 cutback months for LECSA1, 80 cutback months for LECSA2, and 31 cutback months for LECSA3. Alternatives 1bS2-A17.25, 1bS2-m, a2a-B, 2a-m, and Alternative 4-A17.25 slight increases to 33 cutback months for LECSA1, 82 cutback months for LECSA2, and 33 cutback months for LECSA3. Alternative LORS-FWO and Alternative 3-B show a significant reduction to 16 cutback months for LECSA1, 71 cutback months for LECSA2, and 16 cutback months in LECSA3.

D. SSM Sensitivity Simulation

The above general overview of water supply performance measure trends is dependent on the assumption for the SSM line. As previously summarized, modified SSM line and operations are anticipated to be implemented in advance of any new regulation schedule resultant from LORSS; all alternatives (with the exception of the No Action baseline alternative), therefore, assume a one foot lowering of the existing SSM line as a surrogate for the anticipated SSM changes by the SFWMD. Generally, the inclusion of the temporary forward pumps allows for the assumption of

the lowered SSM line, meaning that water supply restrictions would be initiated at lower lake stages than currently in practice. Additional data is available for the evaluation of the Preferred Alternative (Alternative 1bS2-m) through a sensitivity model simulation with the existing SSM line assumed in place (consistent with the No Action Alternative). The assumed lowering of the SSM line does alter the performance of the Preferred Alternative. With the existing SSM line assumed in place with the operational rules of Alternative 1bS2-m, the simulation results show mean annual EAA supplemental demands not met to increase from an average annual volume of 22,000 acre-feet and average drought year (1971, 1975, 1981, 1985, and 1989) volume of 73,000 acre-feet under Alternative 1bS2-m to an average annual volume of 42,000 acre-feet and average drought year volume of 114,000 acre-feet; the percentage of demands not met for the EAA is increased from six to 12 percent for the average year and 16 to 24 percent during the drought years. With the existing SSM line assumed in place with the operational rules of Alternative 1bS2-m, the simulation results show mean annual LOSA supplemental demands not met to increase from an average annual volume of 10,000 acre-feet and average drought year volume of 30,000 acre-feet under Alternative 1bS2-m to an average annual volume of 23,000 acre-feet and average drought year volume of 56,000 acre-feet; the percentage of demands not met for the LOSA is increased from four to ten percent for the average year and nine to 17 percent during the drought years. The number of months of simulated water supply cutbacks for the four LECSAs also show increased cutback months for the Preferred Alternative without the assumption of a lowered SSM line: 33 to 49 months for Northern Palm Beach County; 33 to 49 months for LECSA1; 82 to 95 months for LECSA2; and 33 to 49 months for LECSA3. Select performance measures have been summarized; the complete performance measure set is available on the study web page previously cited (the performance measure set includes “alt1bS2-m-exSSM” in the title and the abbreviation of “mexSSM” on the performance measure set graphics). The SSM Line is set by the SFWMD. Modified SSM rules and a modified SSM line are under development by the SFWMD; these efforts are anticipated to be completed prior to implementation of any new regulatory schedule for Lake Okeechobee, and the efforts will be able to consider the additional data provided from the Preferred Alternative for LORSS. The water supply effects of the alternatives, as shown by a review of the performance measures, must be evaluated with consideration of this parallel and ongoing effort by the SFWMD. The performance measure output is dependent on the SSM line assumption; modification of the SSM line or existing SSM rules (as assumed in place under all alternatives evaluated) will affect the simulated performance, and the nature of the changes will determine the significance of the observed improvement or potential additional impact seen in the simulation results.

SUMMARY

The No Action Alternative, along with seven other alternatives, were modeled using the SFWM. The modeling intent and differences of the alternatives were presented. Model output and post-processed products were used in the selection of the 2006 LORSS SEIS TSP. Selected examples of the model output and performance measures are included as part of this attachment (Figures D-1 through D-32).

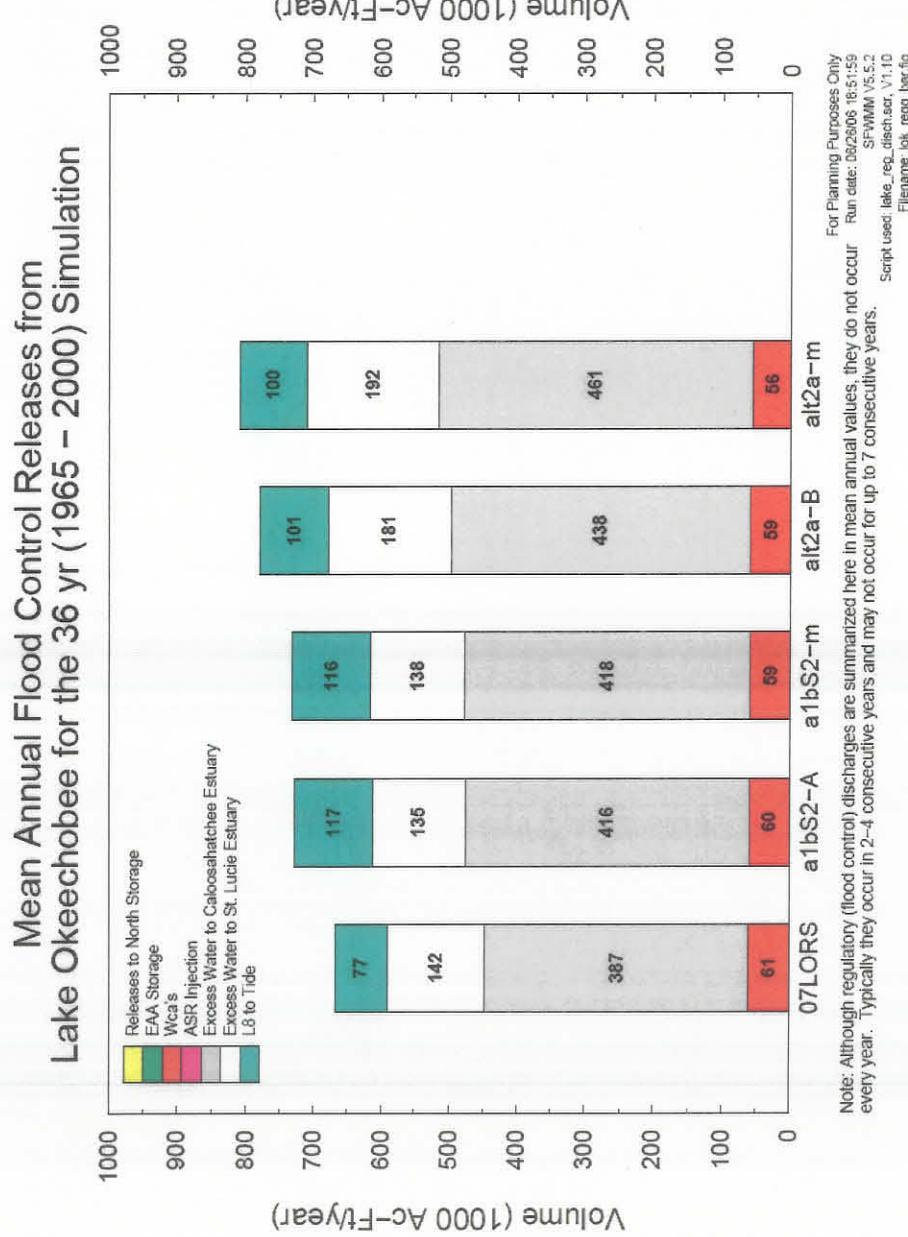


FIGURE D-1: MEAN ANNUAL FLOOD CONTROL RELEASES FROM LAKE OKEECHOBEE (1)

Mean Annual Flood Control Releases from Lake Okeechobee for the 36 yr (1965 – 2000) Simulation

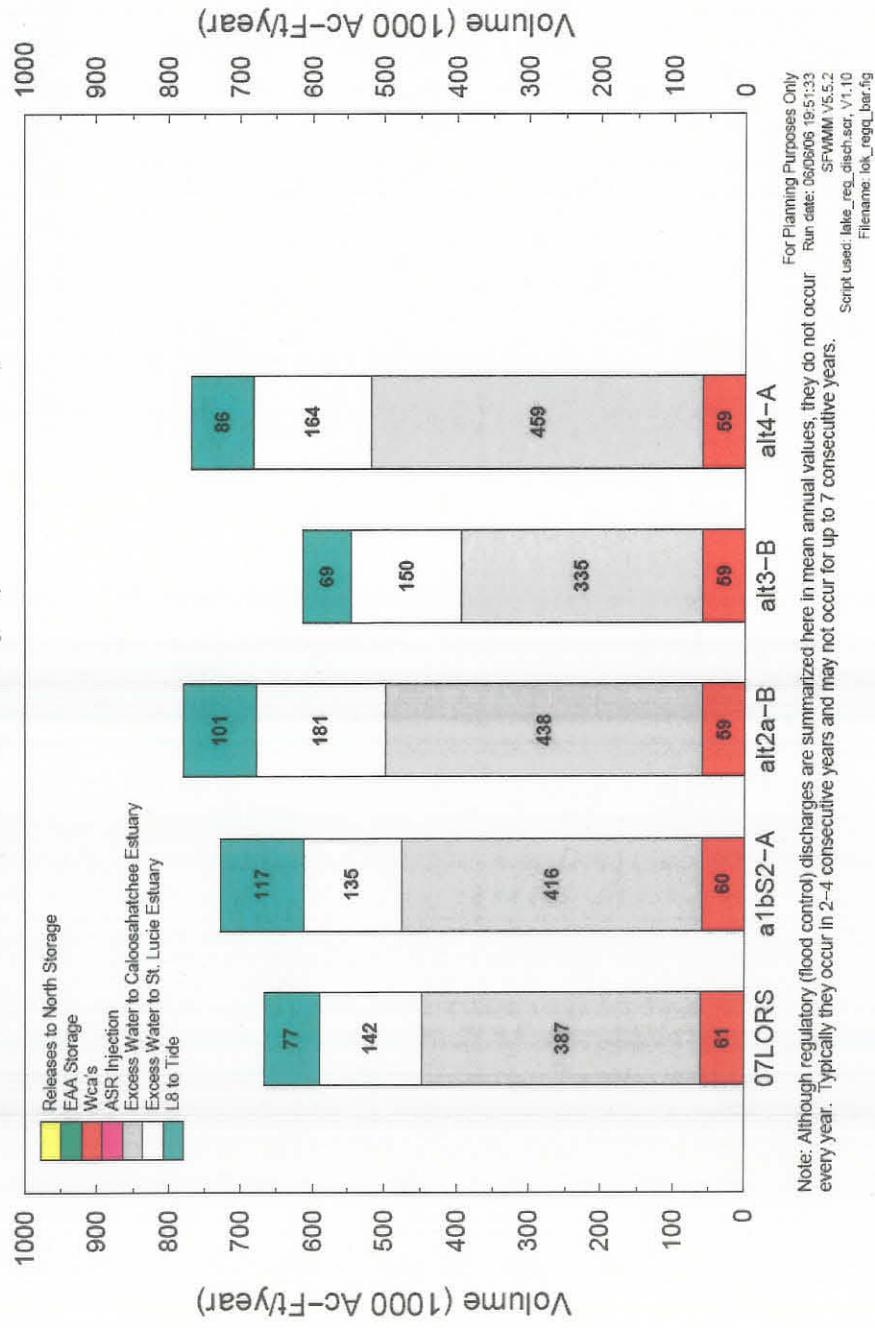


FIGURE D-2: MEAN ANNUAL FLOOD CONTROL RELEASES FROM LAKE OKEECHOBEE (2)

Mean Annual Flood Control Releases from Lake Okeechobee for the 36 yr (1965 – 2000) Simulation

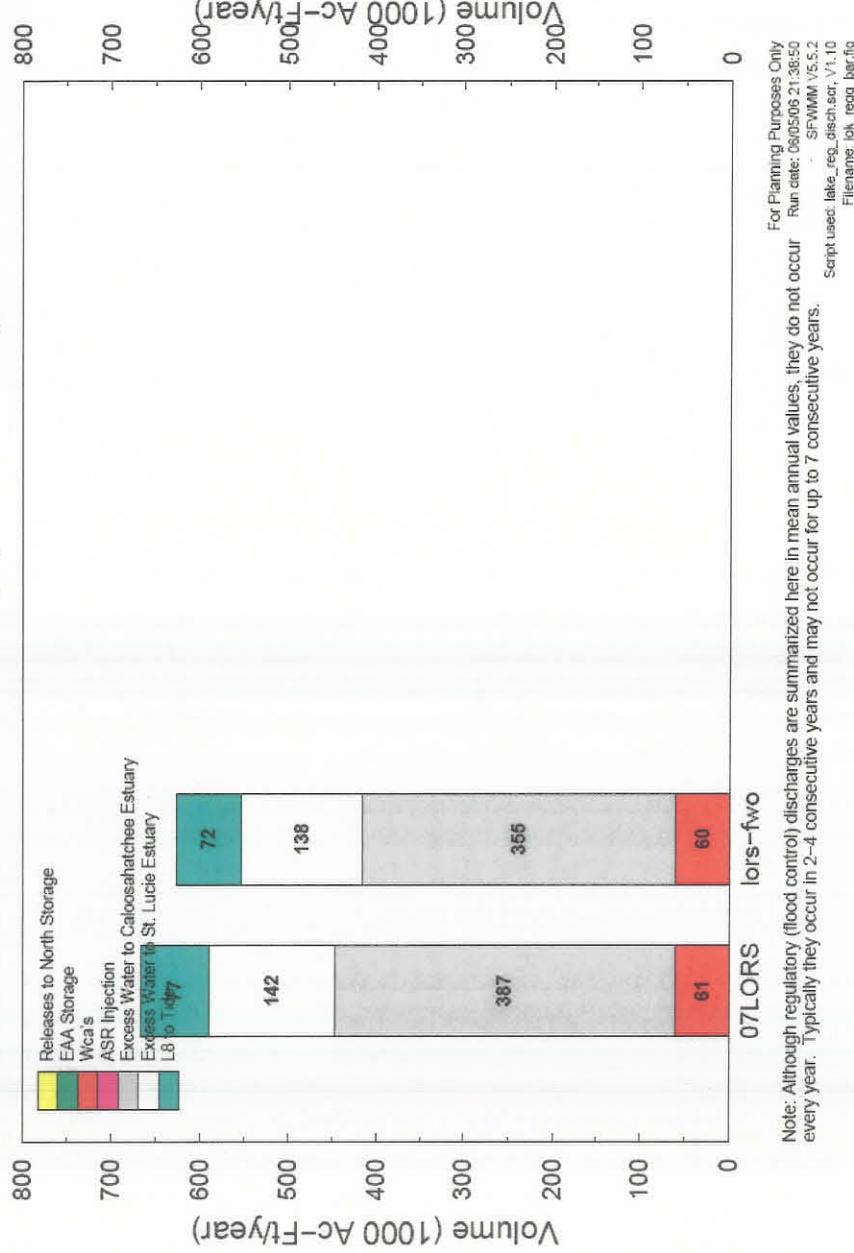


FIGURE D-3: MEAN ANNUAL FLOOD CONTROL RELEASES FROM LAKE OKEECHOBEE (3)

Stage Duration Curves for Lake Okeechobee

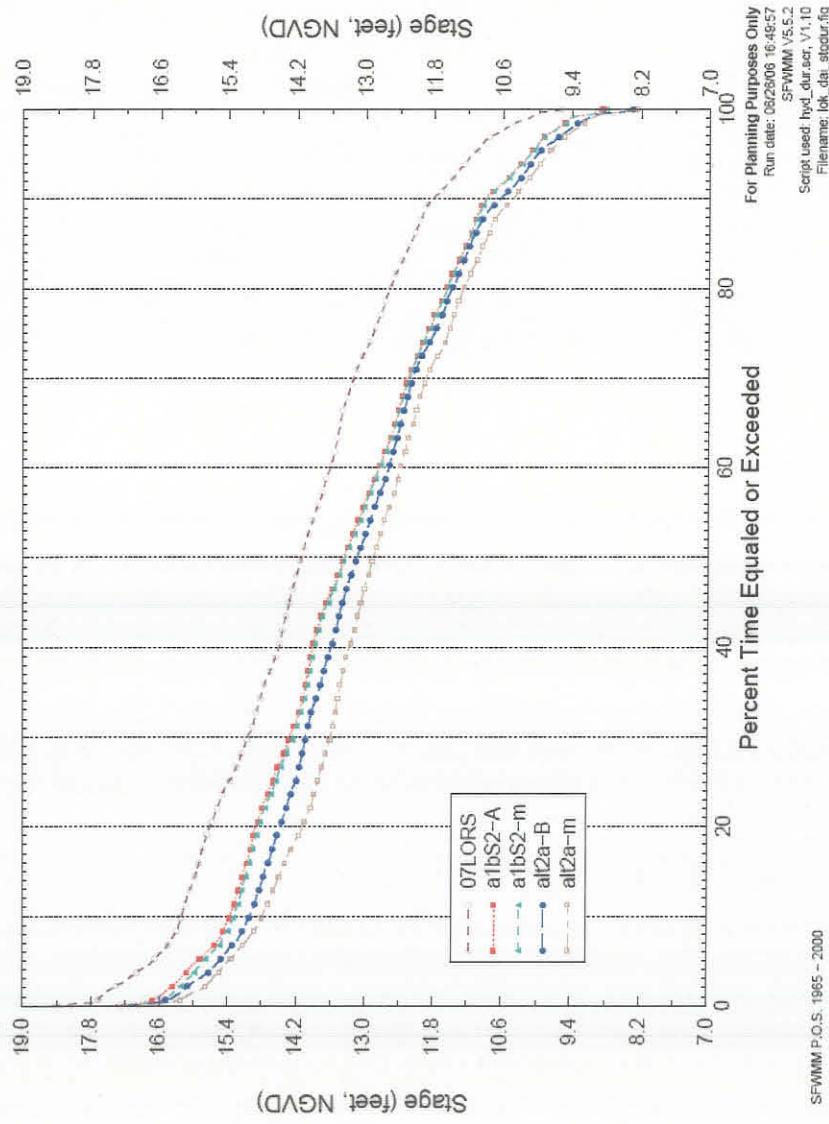


FIGURE D-4: LAKE OKEECHOBEE STAGE DURATION CURVES (1)

Stage Duration Curves for Lake Okeechobee

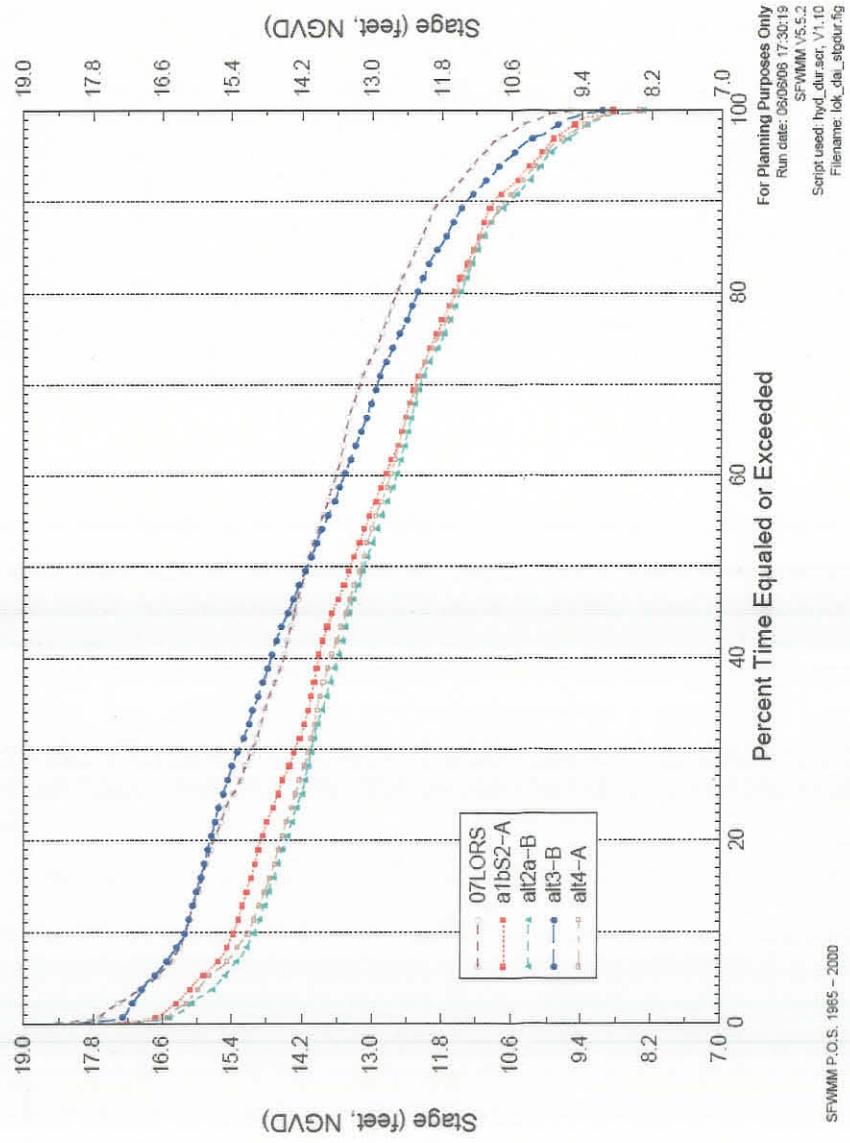


FIGURE D-5: LAKE OKEECHOBEE STAGE DURATION CURVES (2)

Stage Duration Curves for Lake Okeechobee

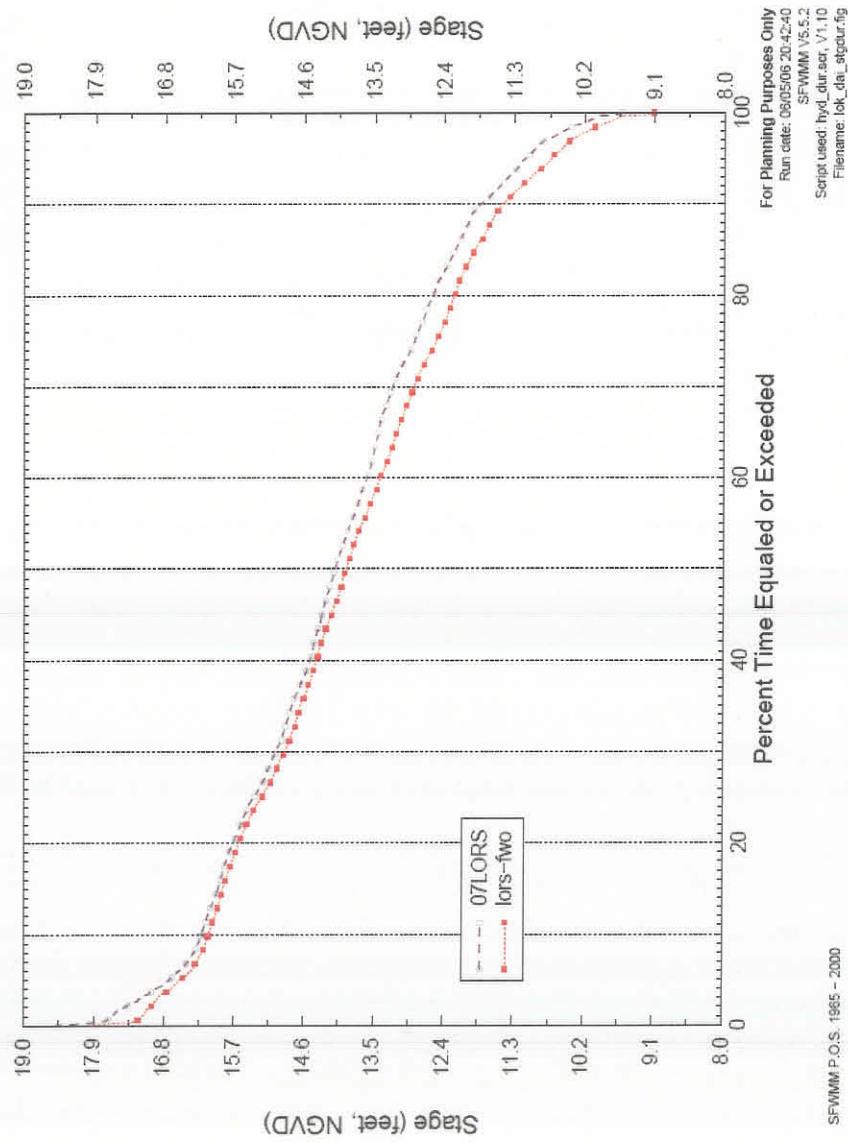


FIGURE D-6: LAKE OKEECHOBEE STAGE DURATION CURVES (3)

**LORSS Summary of Lake Okeechobee High Stages (>16.00),
36-year simulated period-of-record**

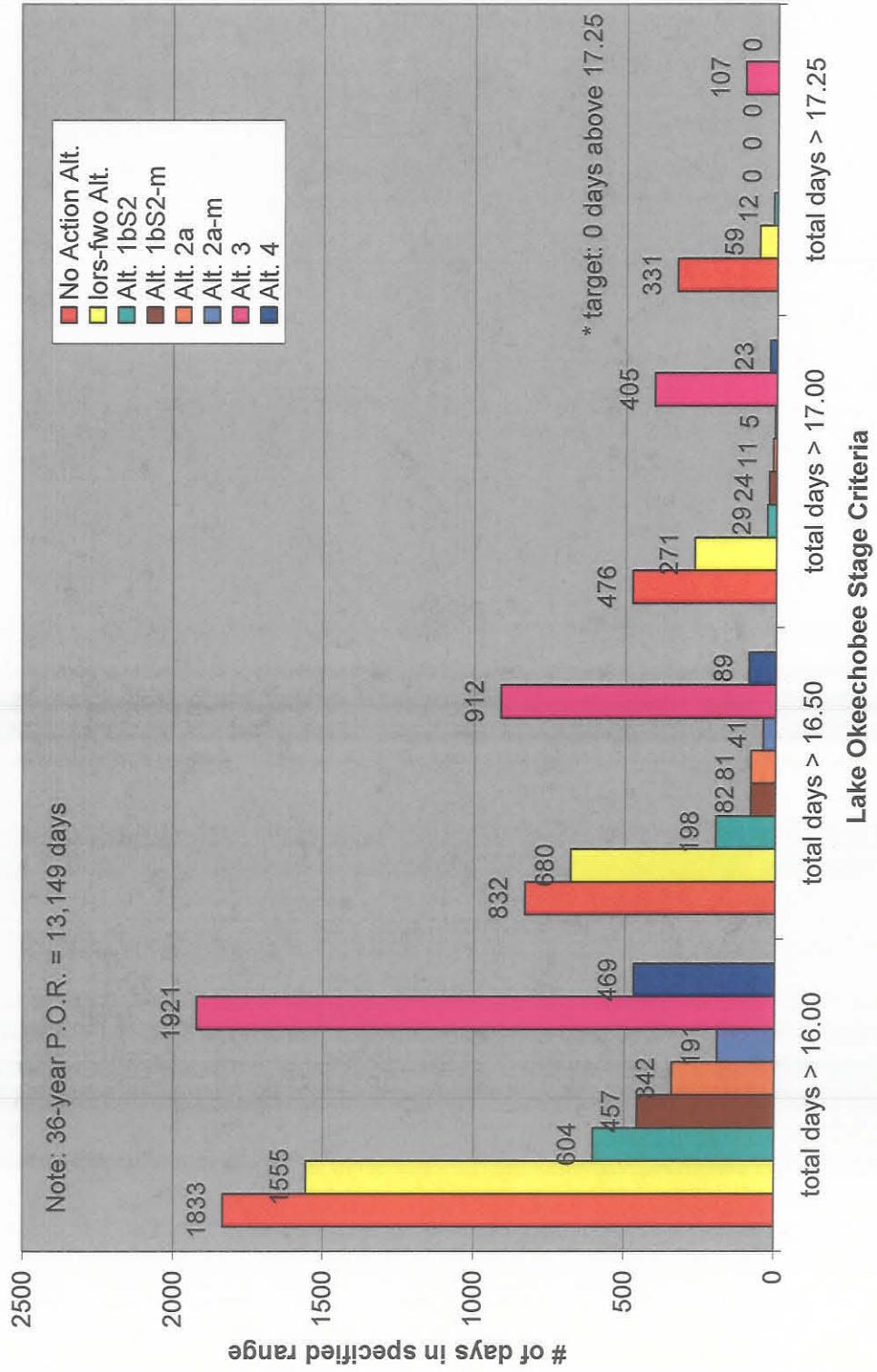


FIGURE D-7: OCCURRENCE FREQUENCY OF LAKE OKEECHOBEE HIGH STAGES

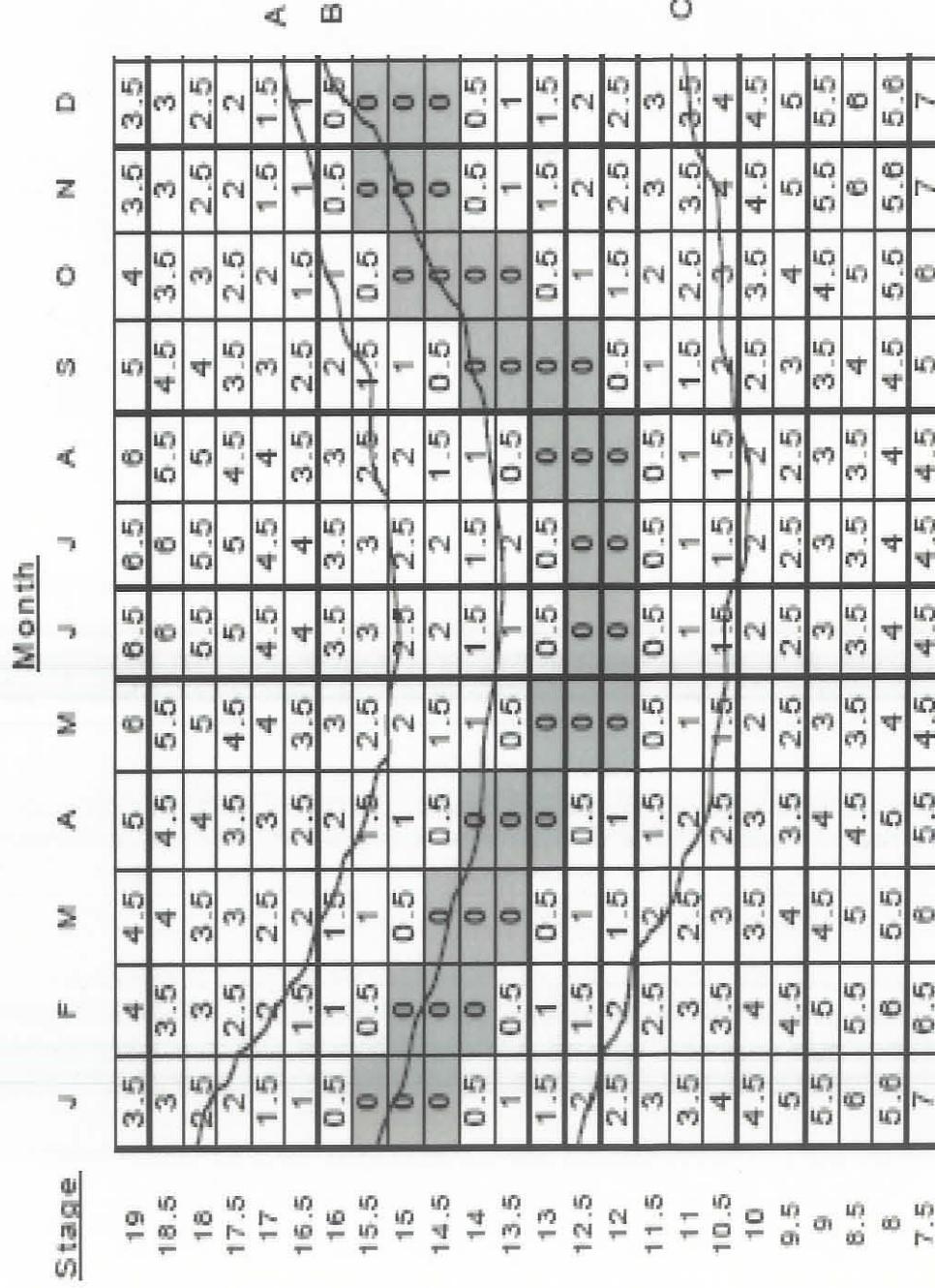


FIGURE D-8: CONCEPTUALIZATION OF LAKE OKEECHOBEE STAGE ENVELOPE PERFORMANCE MEASURE

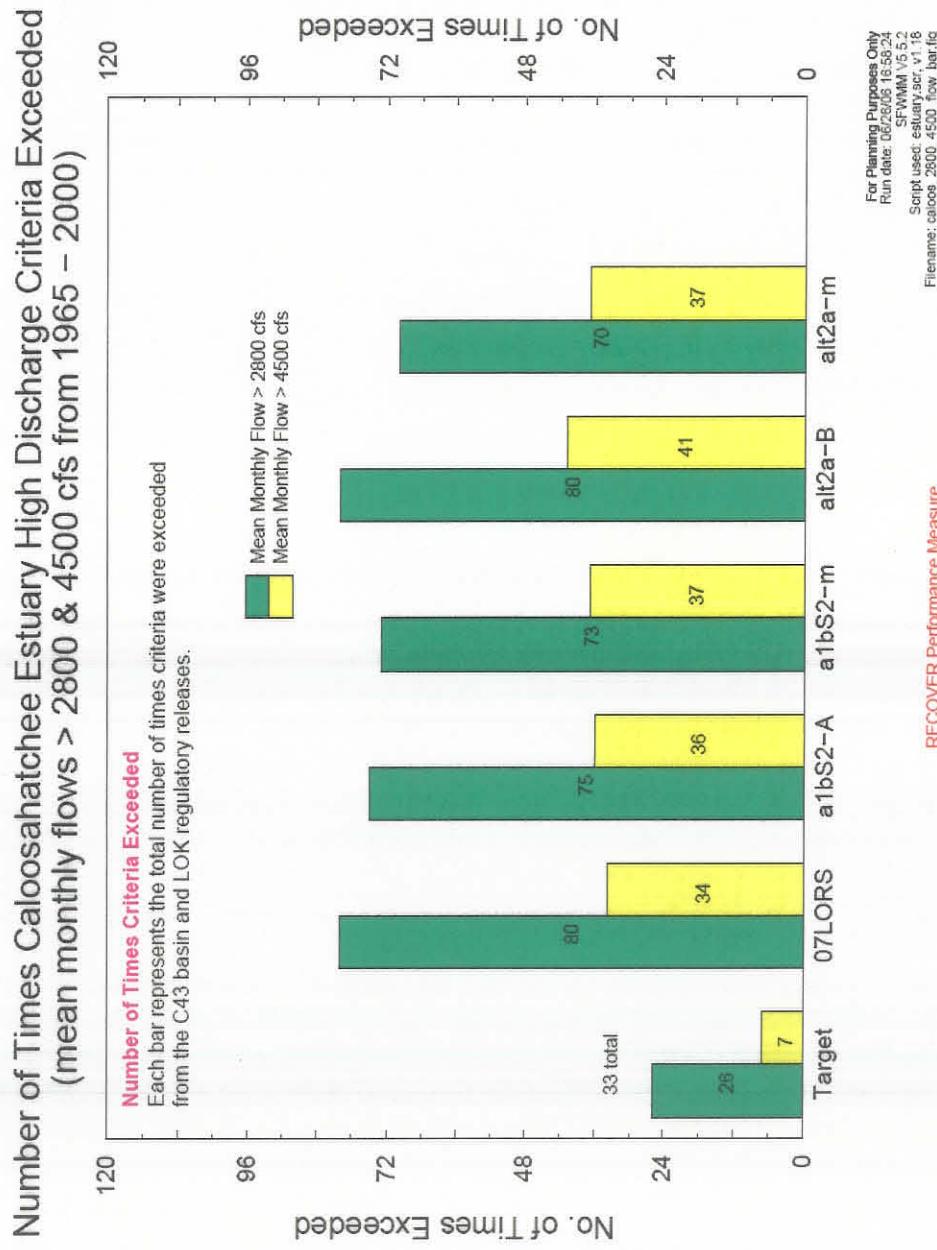


FIGURE D-9: CALOOSA HATCHEE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (1)

**Number of Times Caloosahatchee Estuary High Discharge Criteria Exceeded
(mean monthly flows > 2800 & 4500 cfs from 1965 – 2000)**

Number of Times Criteria Exceeded
Each bar represents the total number of times criteria were exceeded from the C43 basin and LOK regulatory releases.

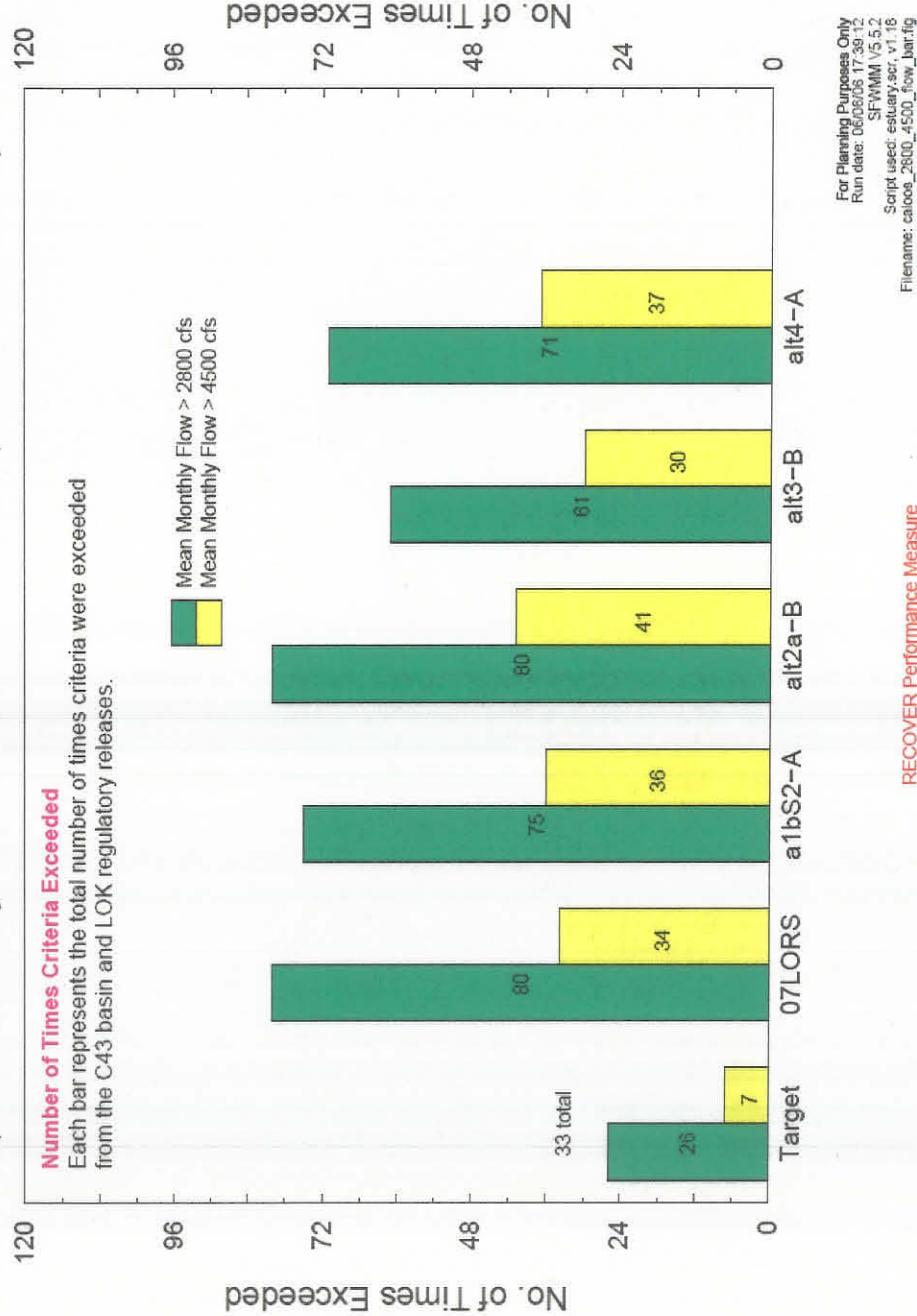


FIGURE D-10: CALOOSAHTCHEE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (2)

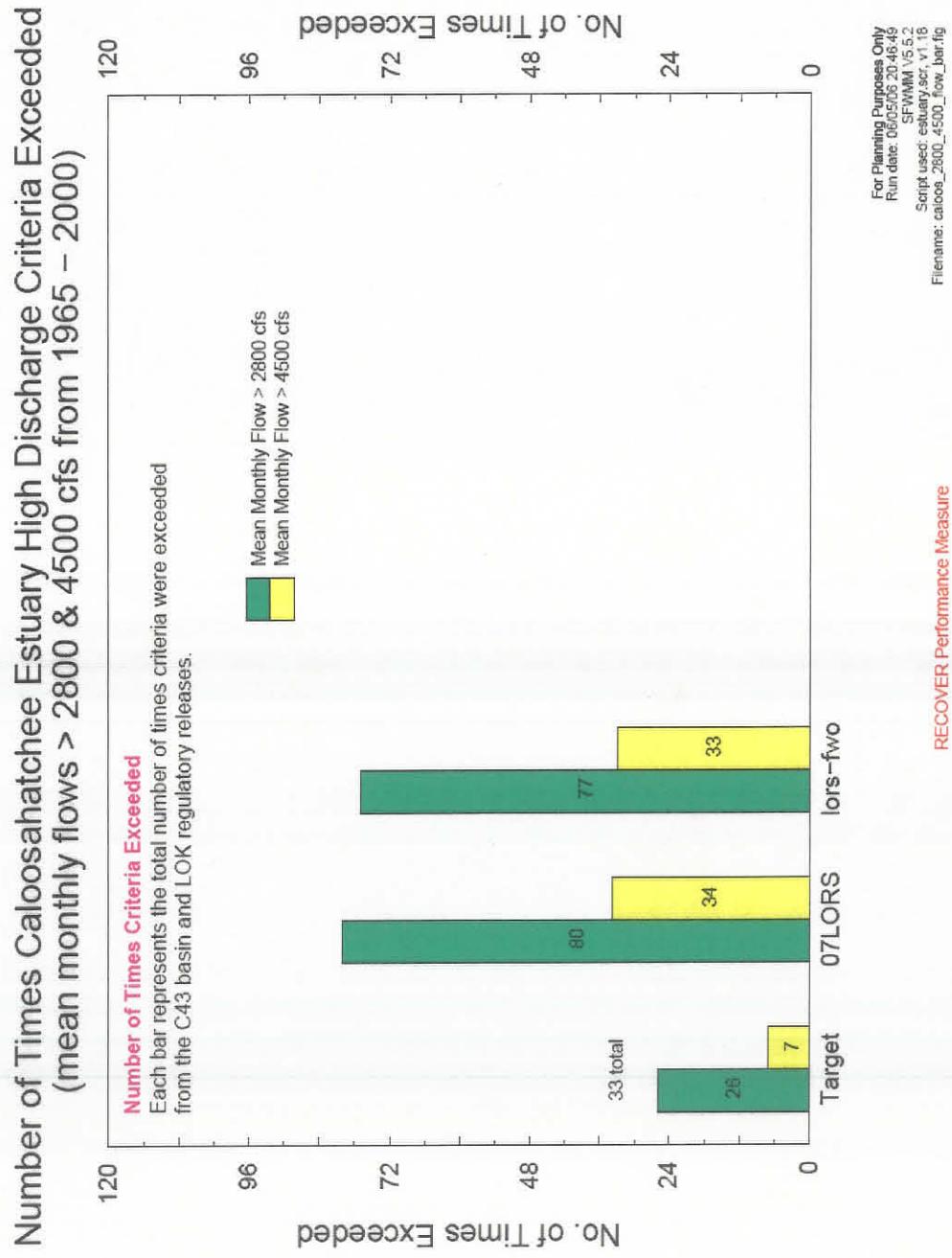


FIGURE D-11: CALOOSAHTACHEE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (3)

Number of Times St. Lucie High Discharge Criteria Exceeded (mean monthly flows > 2000 cfs from 1965 – 2000)

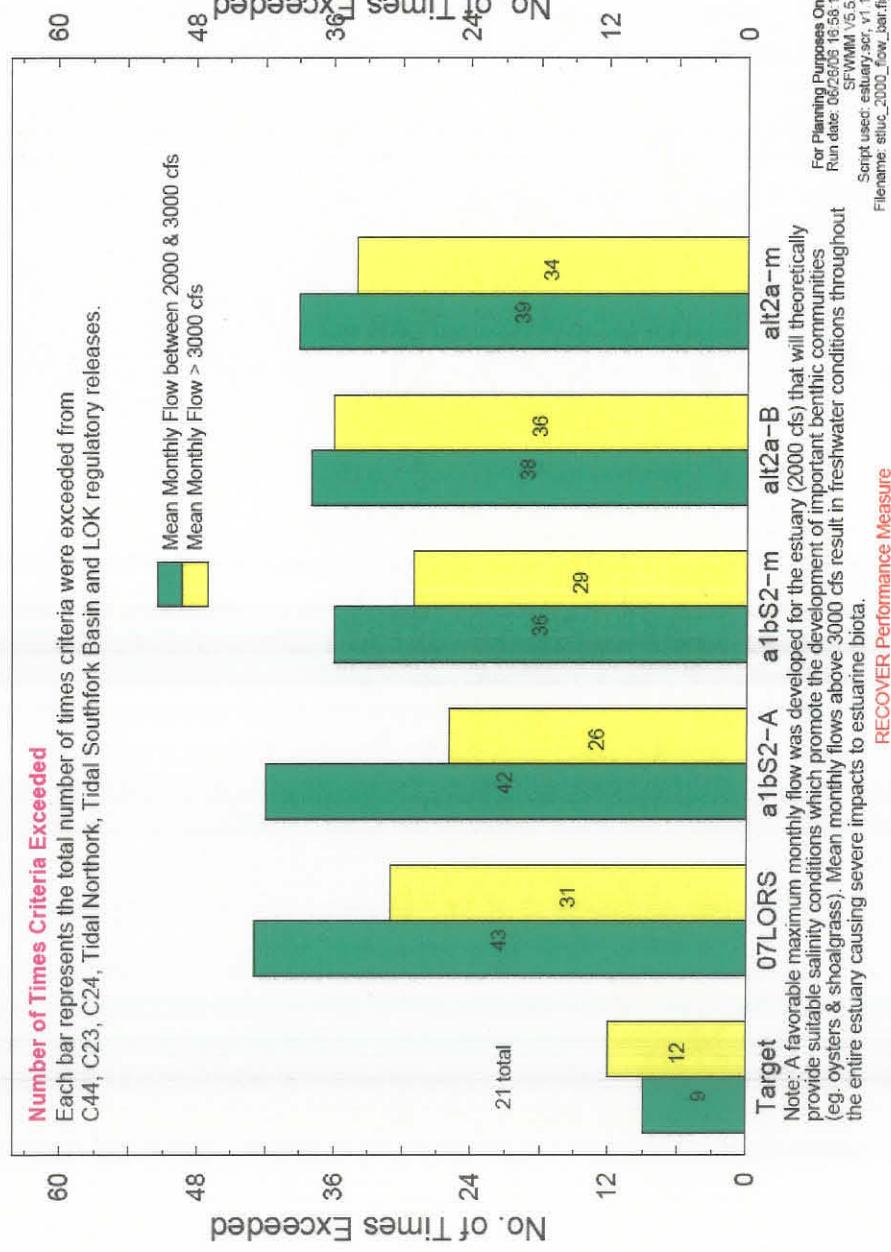


FIGURE D-12: ST. LUCIE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (1)

Number of Times St. Lucie High Discharge Criteria Exceeded (mean monthly flows > 2000 cfs from 1965 – 2000)

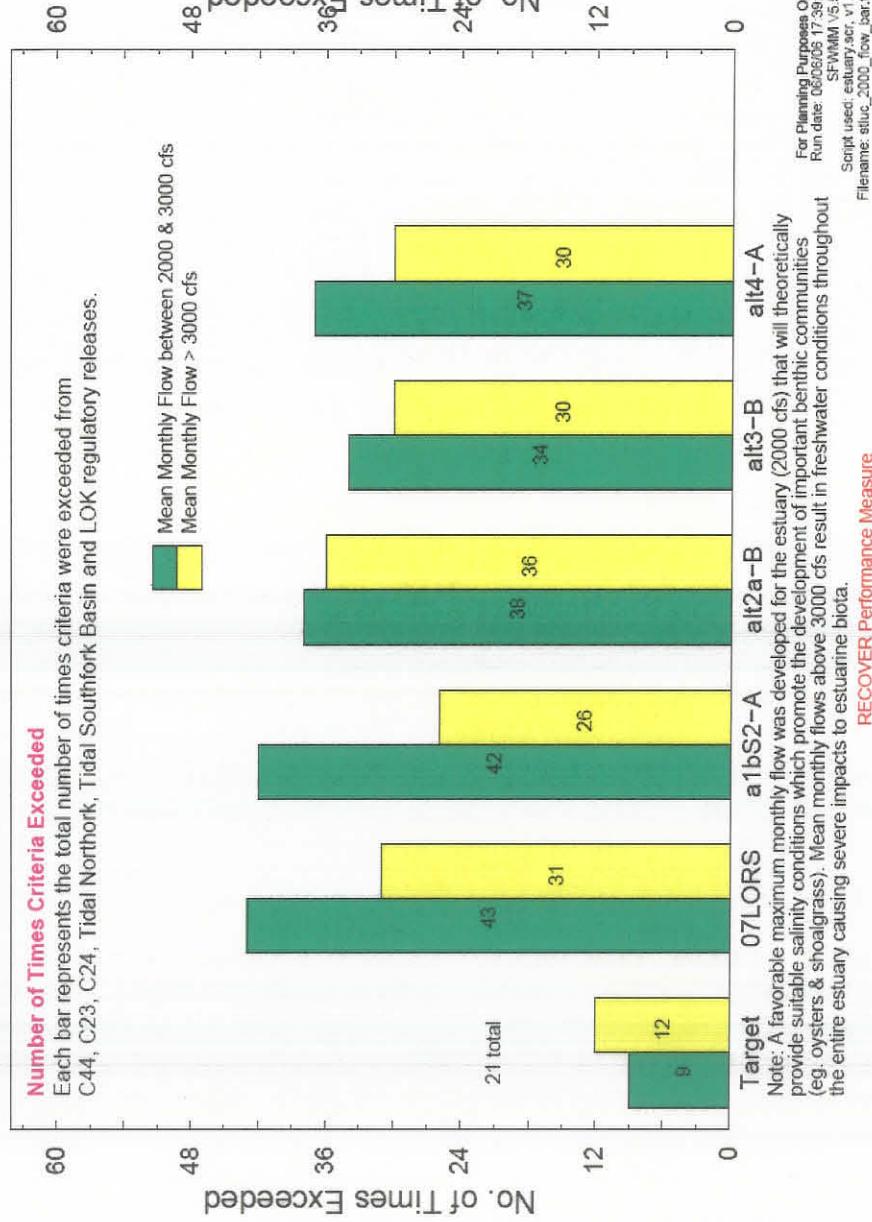


FIGURE D-13: ST. LUCIE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (2)

Number of Times St. Lucie High Discharge Criteria Exceeded (mean monthly flows > 2000 cfs from 1965 – 2000)

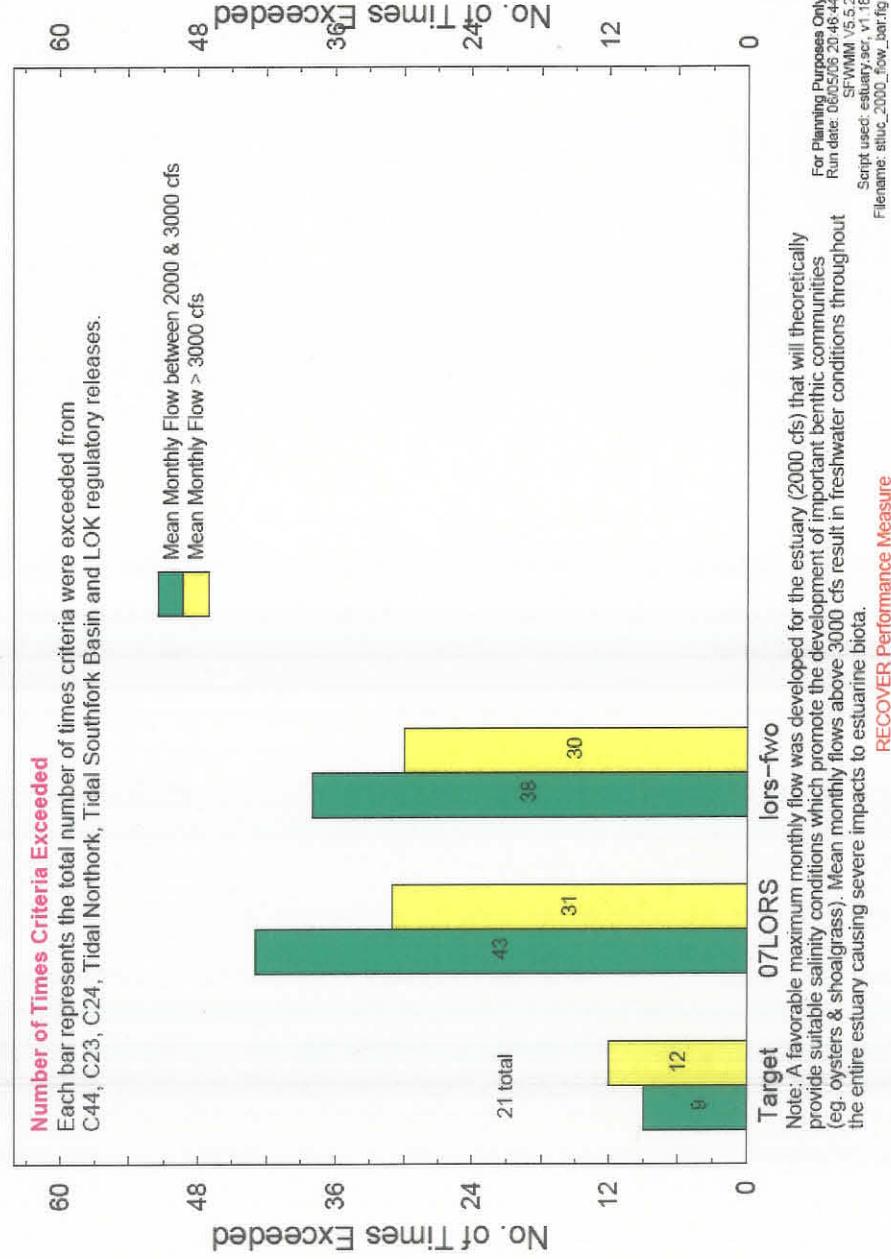


FIGURE D-14: ST. LUCIE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (3)

Number of times Salinity Envelope Criteria were NOT met for Lake Worth Lagoon (mean monthly flows 1965 – 2000)

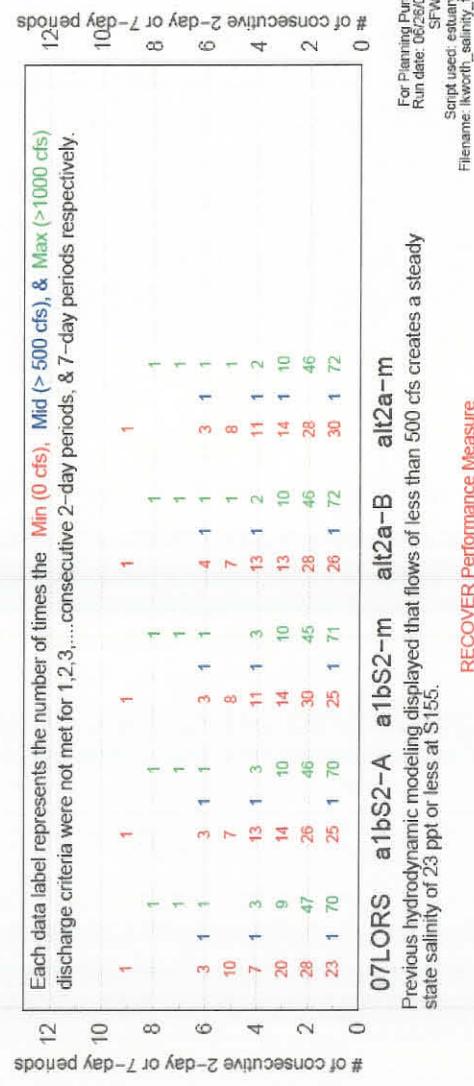
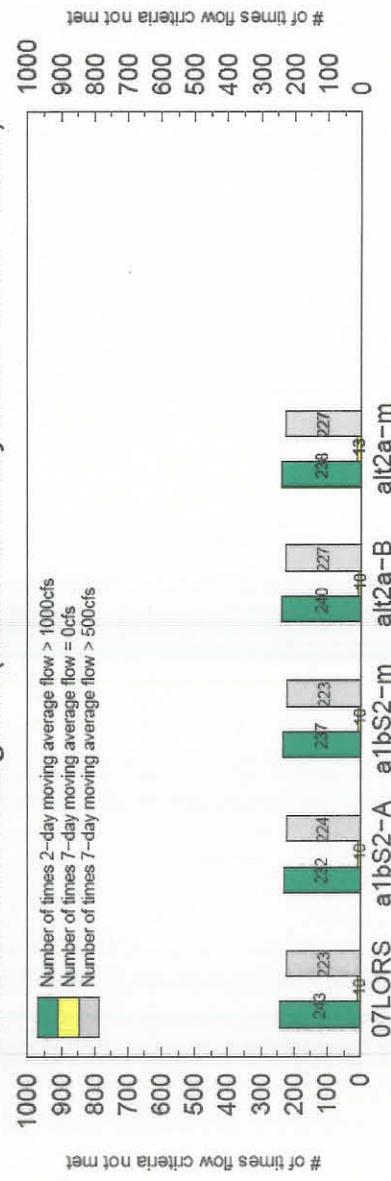
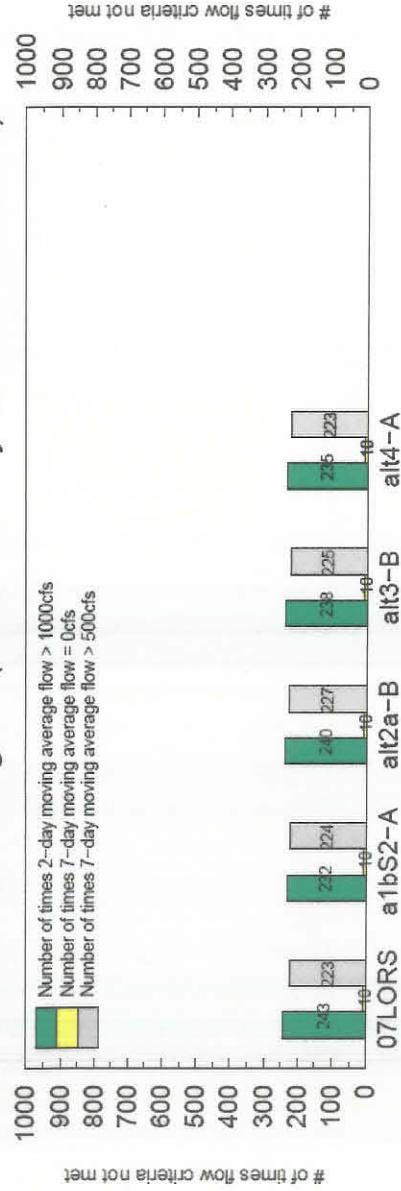
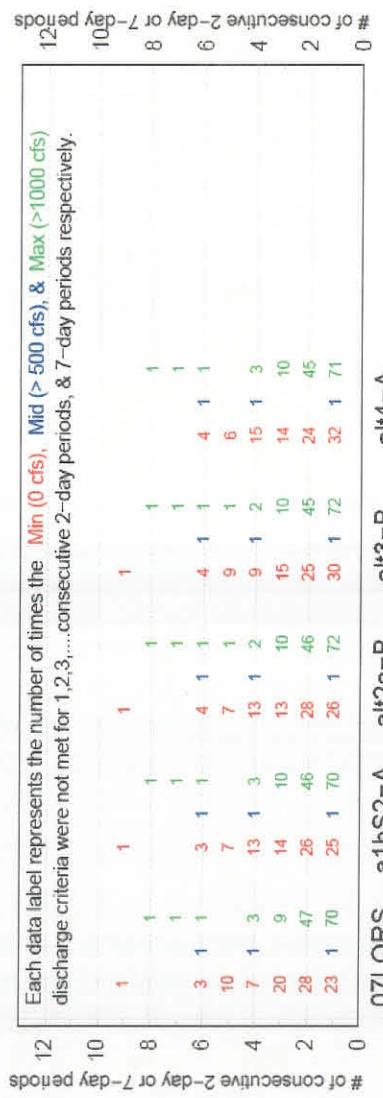


FIGURE D-15: LAKE WORTH LAGOON SALINITY ENVELOPE (1)

Number of times Salinity Envelope Criteria were NOT met for Lake Worth Lagoon (mean monthly flows 1965 - 2000)



Each data label represents the number of times the **Min (0 cfs)**, **Mid (>500 cfs)**, & **Max (>1000 cfs)** discharge criteria were not met for 1,2,3,...consecutive 2-day periods, & 7-day periods respectively.



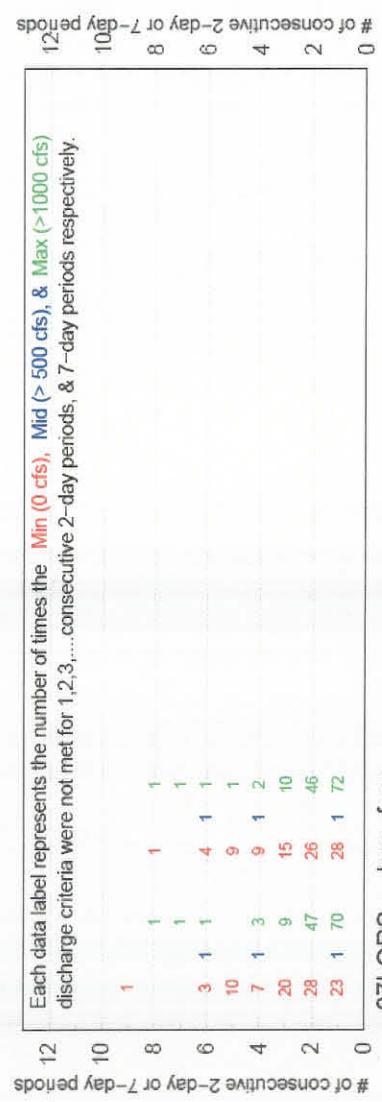
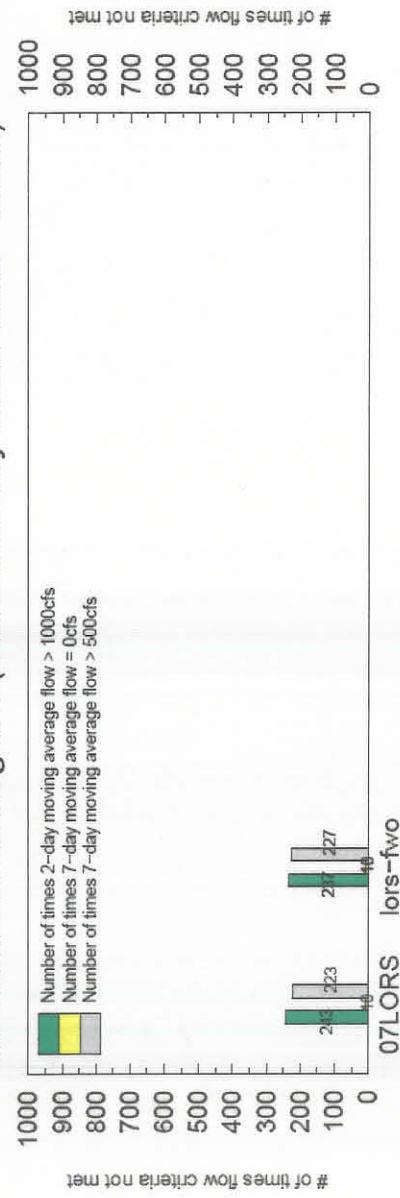
Previous hydrodynamic modeling displayed that flows of less than 500 cfs creates a steady state salinity of 23 ppt or less at S150.

RECOVER Performance Measure

For Planning Purposes Only
Run date: 06/06/05 17:39:34
SFWMMA v5.5.2
Script used: estuary.scr_v1.18
Filename: lworth_salinity_flow_bar.fgf

FIGURE D-16: LAKE WORTH LAGOON SALINITY ENVELOPE (2)

Number of times Salinity Envelope Criteria were NOT met for Lake Worth Lagoon (mean monthly flows 1965 – 2000)



For Planning Purposes Only
Run date: 06/15/05 20:47:06
SFWMMA v5.5.2
Script used: estuary.ser, v1.18
Filename: lworth_salinity_low_barfig

RECOVER Performance Measure

Previous hydrodynamic modeling displayed that flows of less than 500 cfs creates a steady state salinity of 23 ppt or less at S155.

FIGURE D-17: LAKE WORTH LAGOON SALINITY ENVELOPE (3)

Simulated Mean Seasonal Structure Flows Discharged into Biscayne Bay for 1965 – 2000

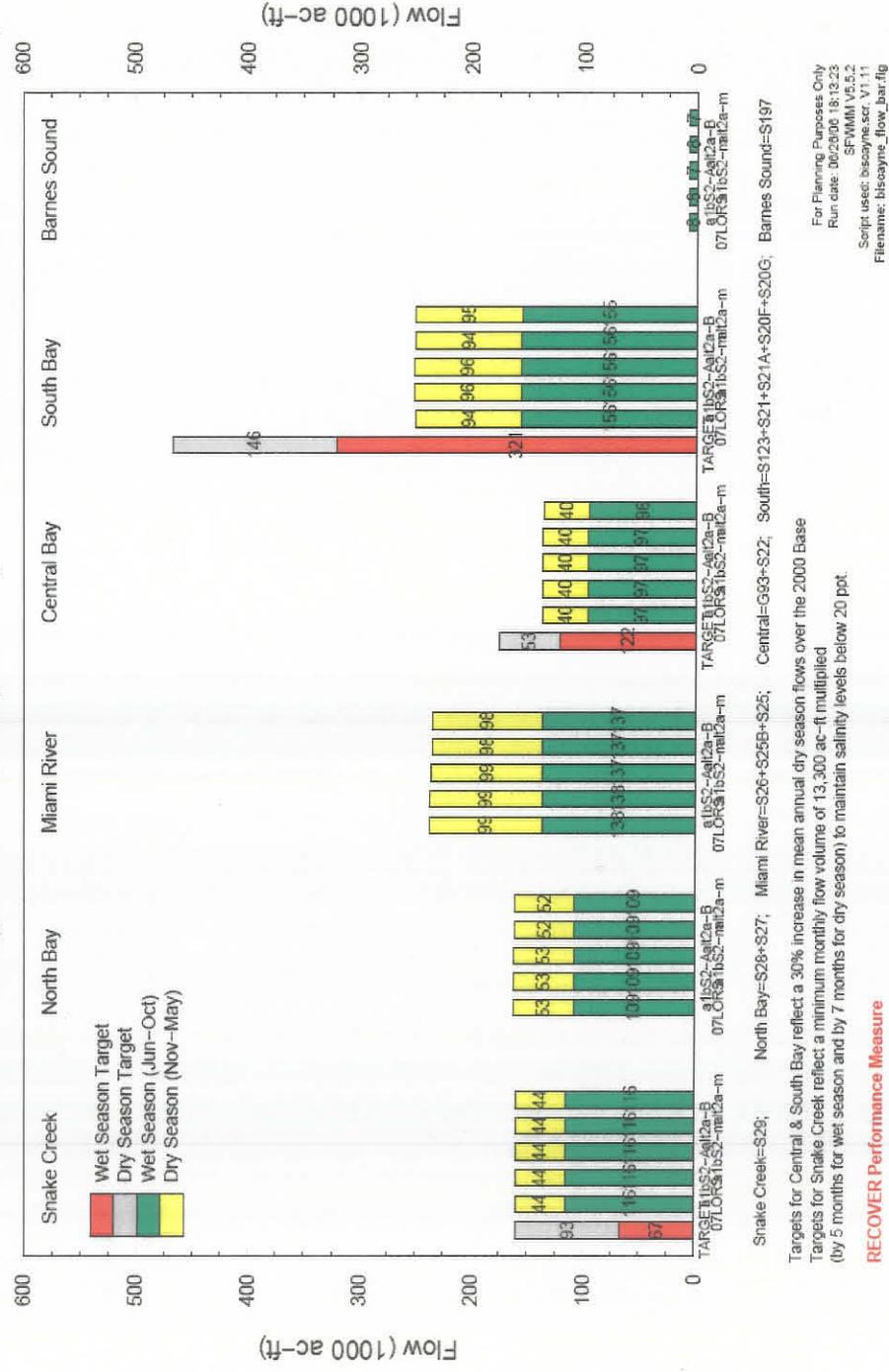


FIGURE D-18: MEAN SEASONAL STRUCTURE FLOWS DISCHARGED TO BISCAYNE BAY (1)

Simulated Mean Seasonal Structure Flows Discharged into Biscayne Bay for 1965 – 2000

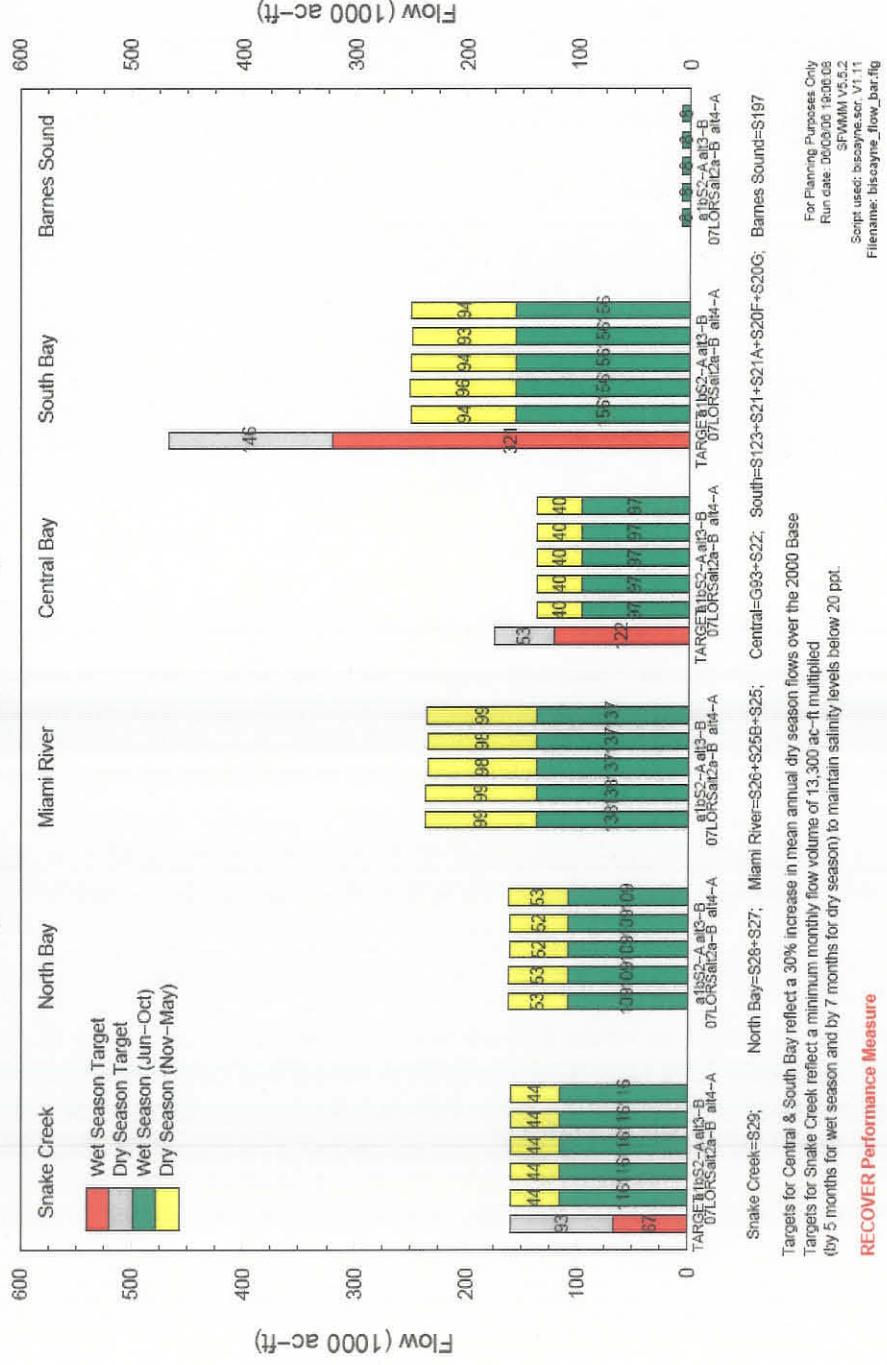
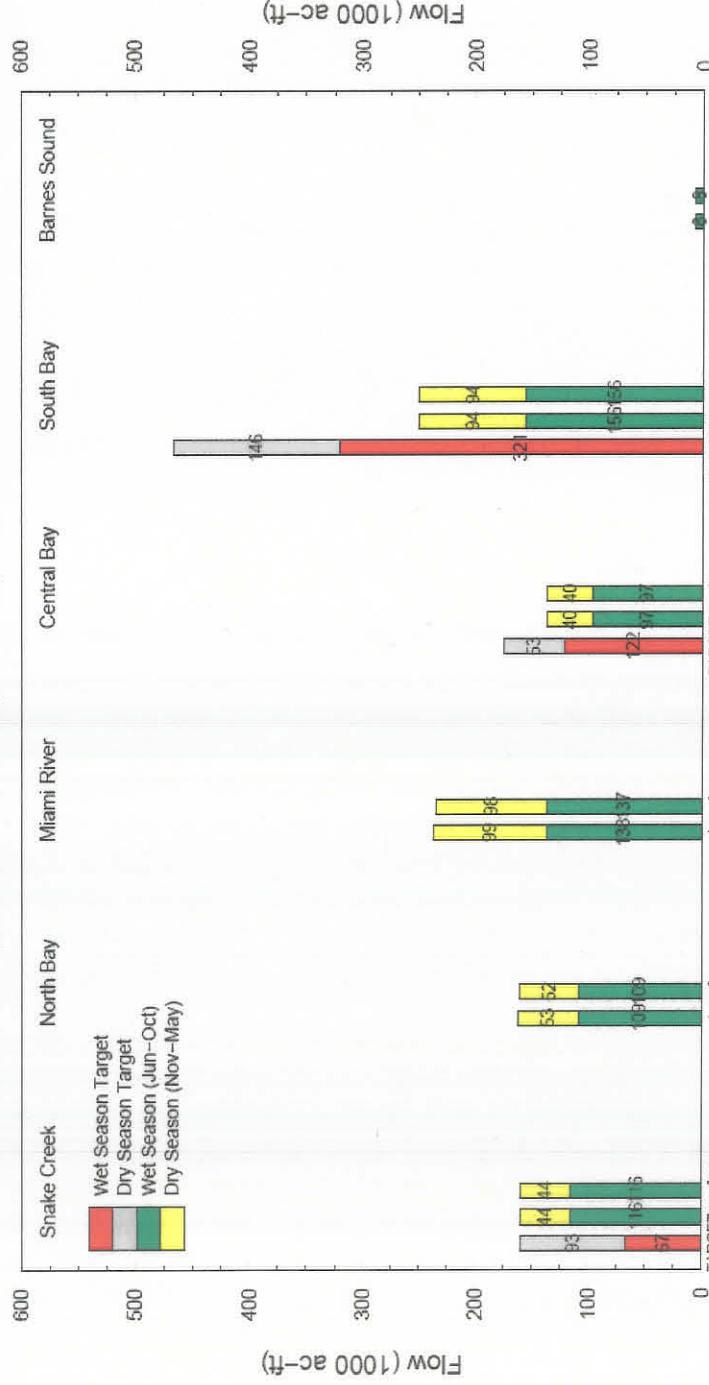


FIGURE D-19: MEAN SEASONAL STRUCTURE FLOWS DISCHARGED TO BISCAYNE BAY (2)

Simulated Mean Seasonal Structure Flows Discharged into Biscayne Bay for 1965 – 2000



Targets for Central & South Bay reflect a 30% increase in mean annual dry season flows over the 2000 Base
Targets for Snake Creek reflect a minimum monthly flow volume of 13,300 ac-ft multiplied
(by 5 months for wet season and by 7 months for dry season) to maintain salinity levels below 20 ppt.

RECOVER Performance Measure

For Planning Purposes Only
Run date: Dec04/06 2:12:19
SFWMM V5.5.2
Script used: biscayne.ser, v1.11
Filename: biscayne_flow_bar.fig

FIGURE D-20: MEAN SEASONAL STRUCTURE FLOWS DISCHARGED TO BISCAYNE BAY (3)

Average Annual Overland Flow across Transects 21, 22 & 23 (1965–2000)
 Westward & Southward flows towards Whitewater Bay & Florida Bay

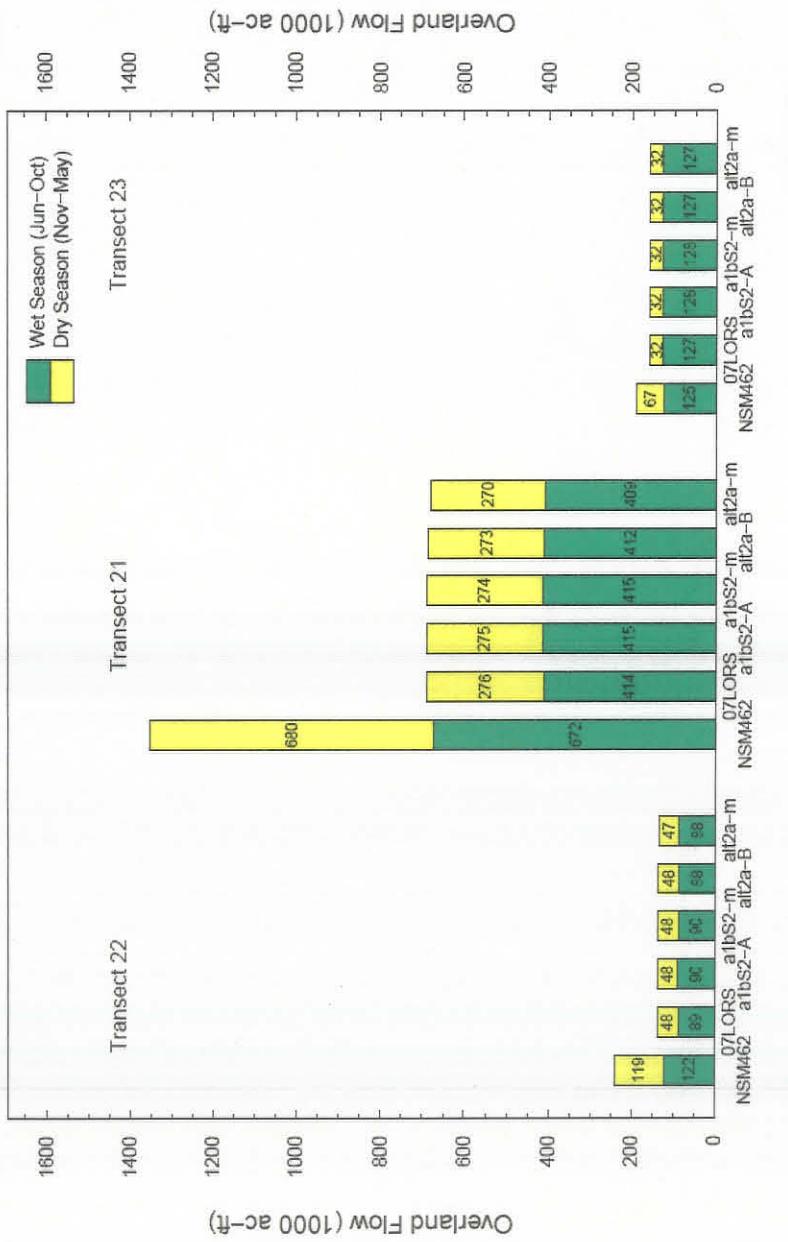


FIGURE D-21: AVERAGE ANNUAL OVERLAND FLOWS TOWARDS WHITEWATER BAY AND FLORIDA BAY (1)

Average Annual Overland Flow across Transects 21, 22 & 23 (1965–2000)
Westward & Southward flows towards Whitewater Bay & Florida Bay

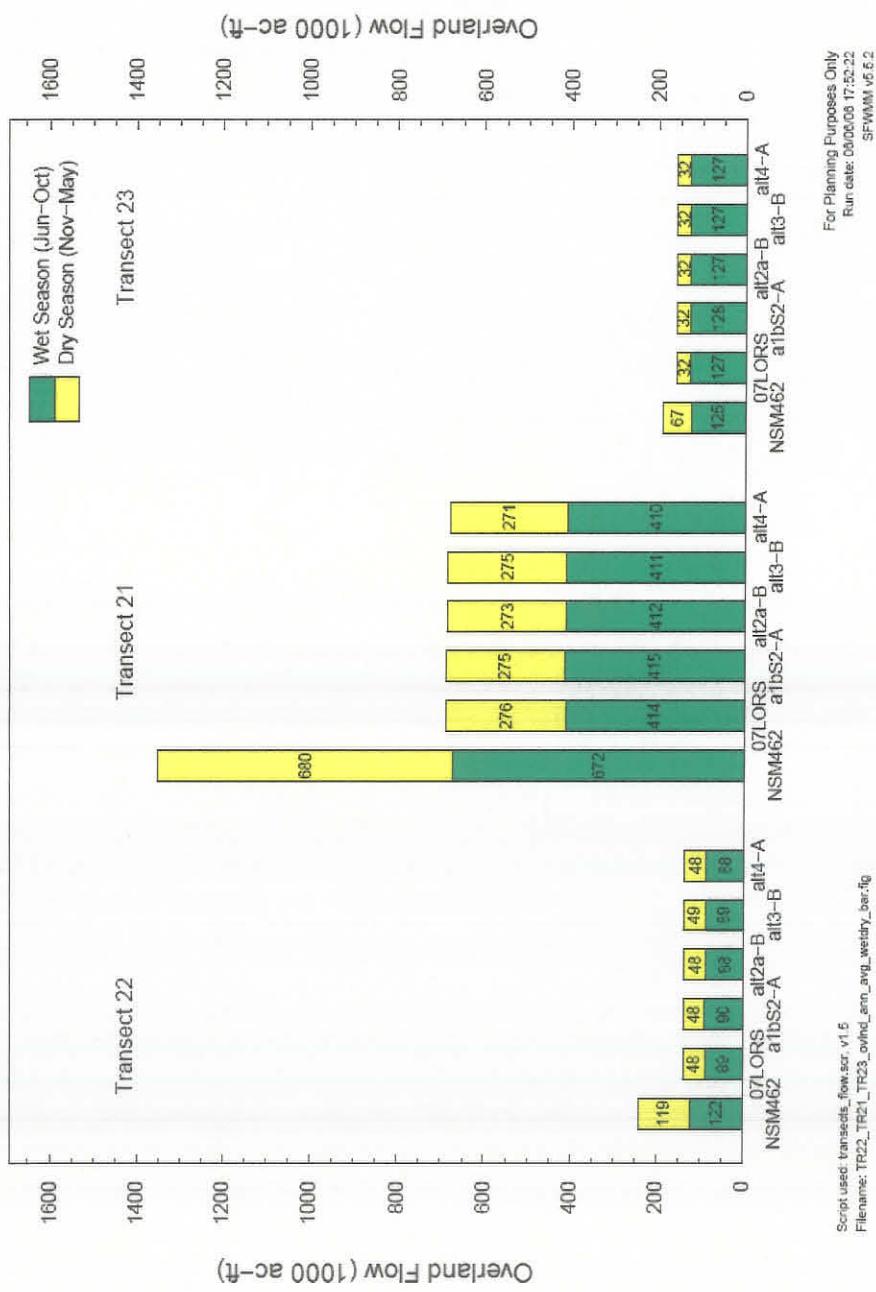


FIGURE D-22: AVERAGE ANNUAL OVERLAND FLOWS TOWARDS WHITEWATER BAY AND FLORIDA BAY (2)

Average Annual Overland Flow across Transects 21, 22 & 23 (1965–2000)
 Westward & Southward flows towards Whitewater Bay & Florida Bay

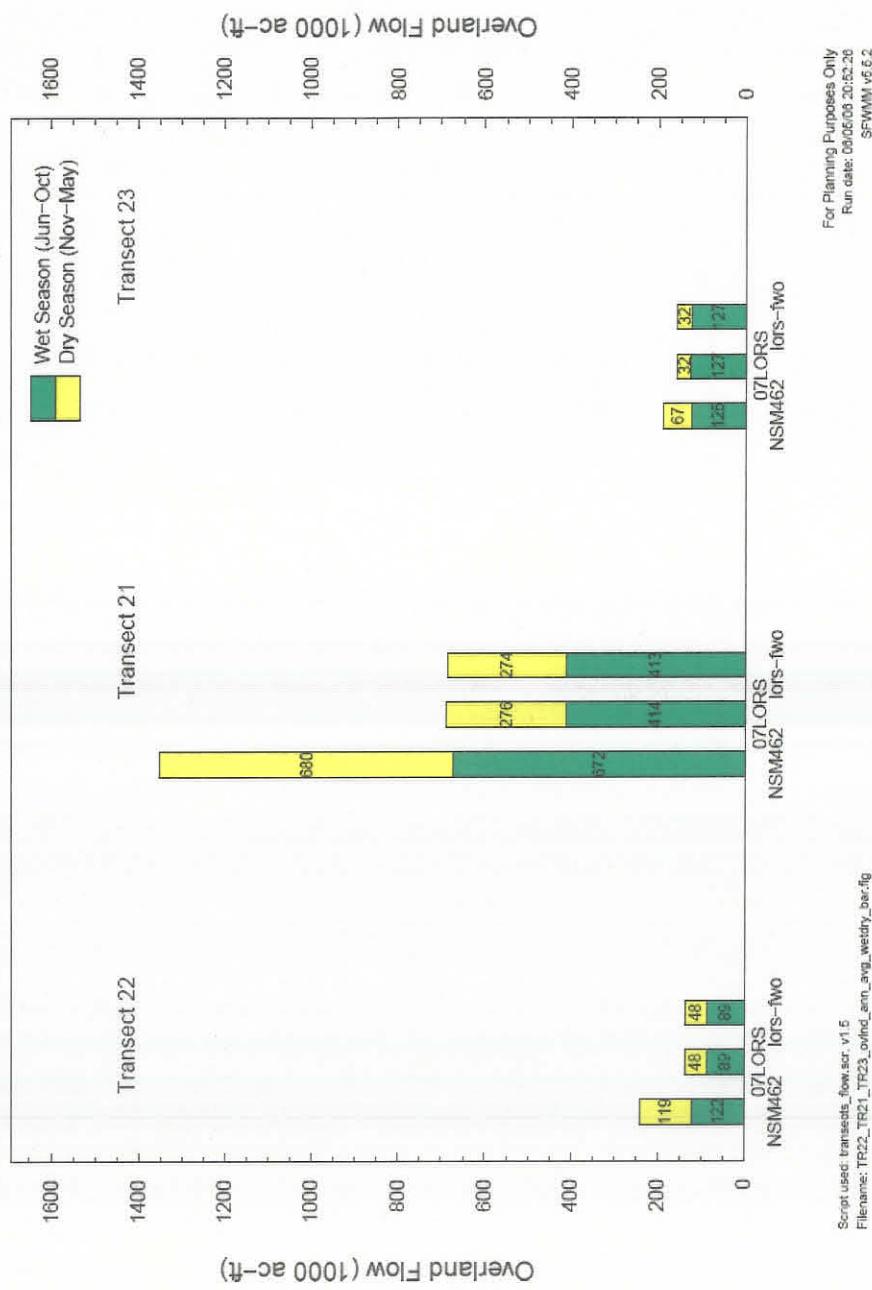


FIGURE D-23: AVERAGE ANNUAL OVERLAND FLOWS TOWARDS WHITEWATER BAY AND FLORIDA BAY (3)

Average Annual Overland Flow across Transects 17 & 18 (1965–2000)
 Southward flow in Northern ENP (south of Tamiami Trail – east and west of L–67 extension)

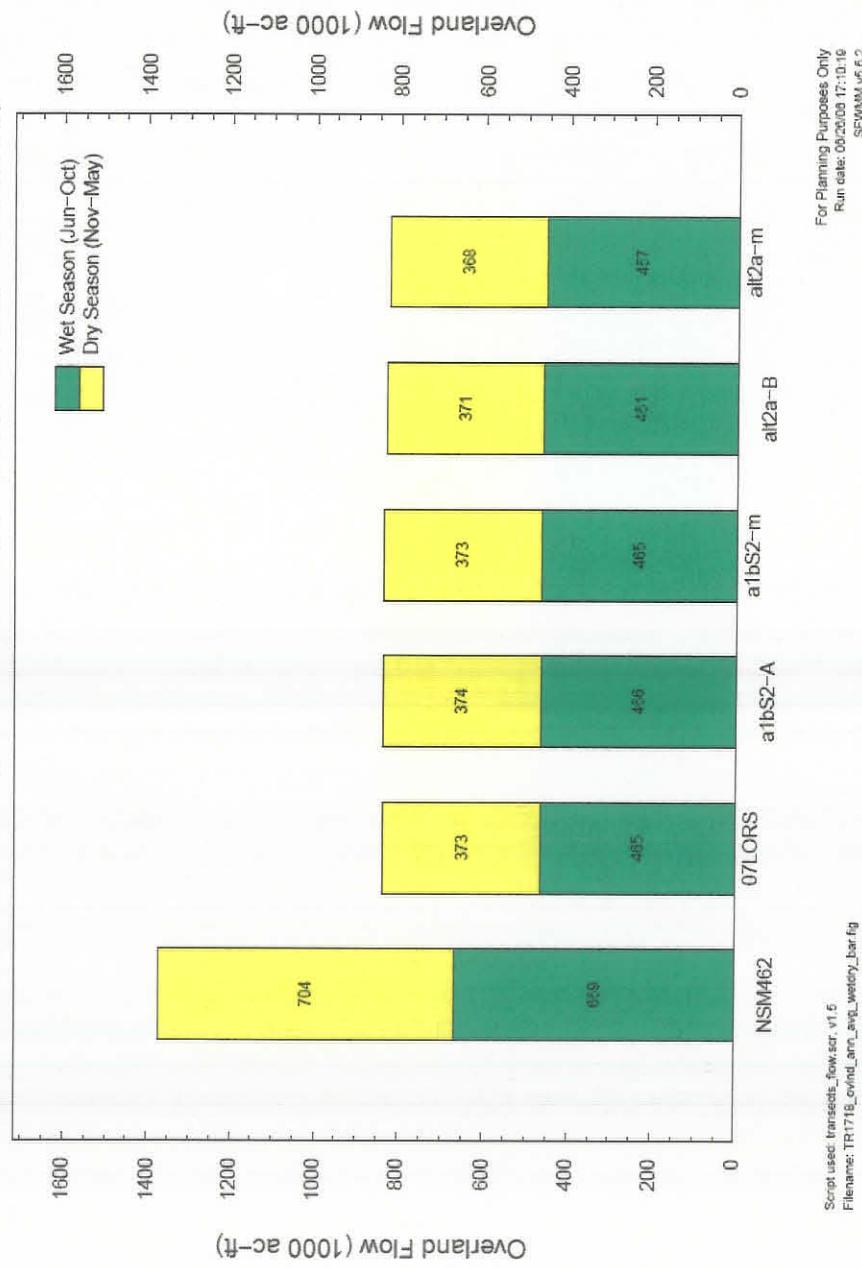


FIGURE D-24: AVERAGE ANNUAL OVERLAND FLOWS TO NORTHERN ENP (1)

Average Annual Overland Flow across Transects 17 & 18 (1965–2000)
Southward flow in Northern ENP (south of Tamiami Trail – east and west of L-67 extension)

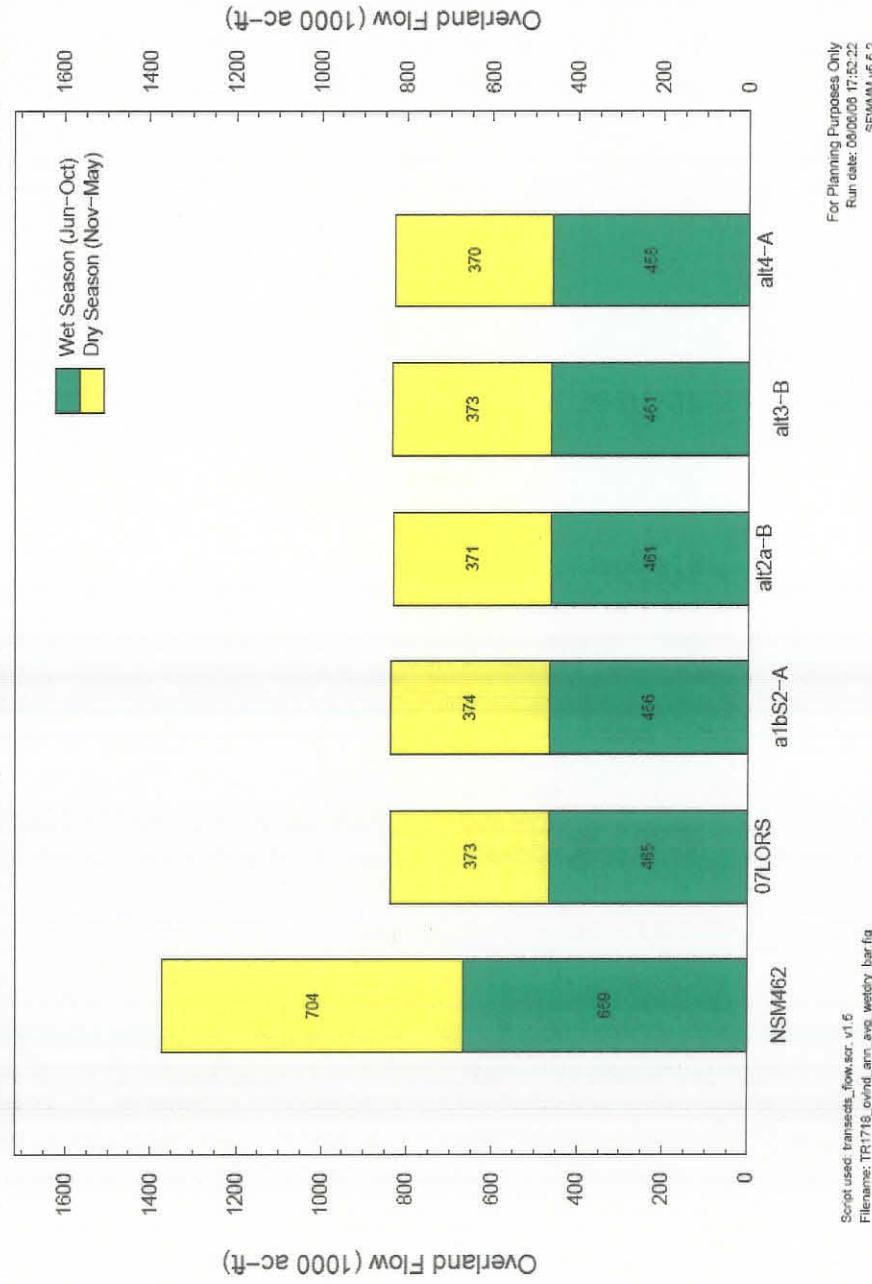


FIGURE D-25: AVERAGE ANNUAL OVERLAND FLOWS TO NORTHERN ENP (2)

Average Annual Overland Flow across Transects 17 & 18 (1965–2000)
Southward flow in Northern ENP (south of Tamiami Trail – east and west of L-67 extension)

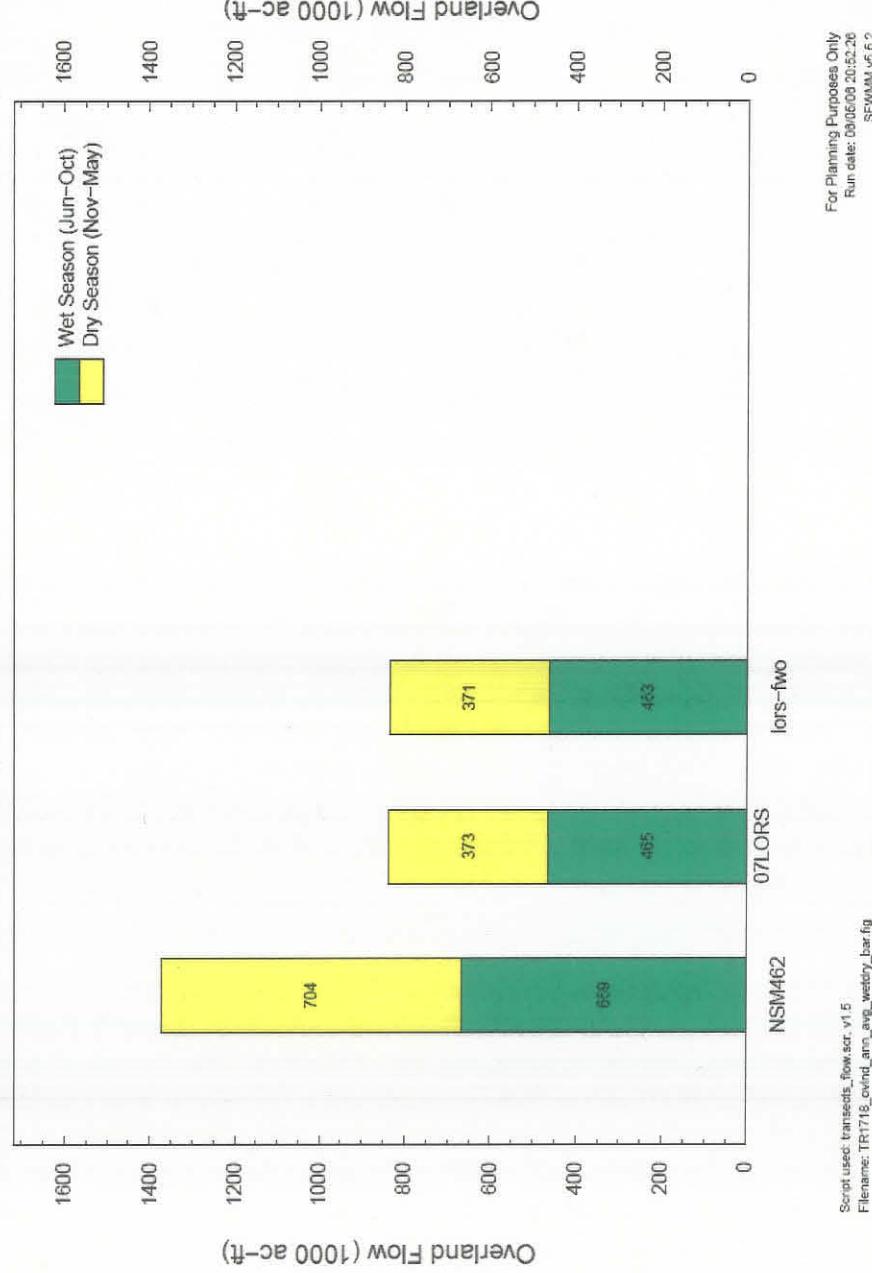


FIGURE D-26: AVERAGE ANNUAL OVERLAND FLOWS TO NORTHERN ENP (3)

**Mean Annual EAA/LOSA Supplemental Irrigation:
Demands & Demands Not Met from 1965 – 2000
For Drought Years: 1971 1975 1981 1985 1989**

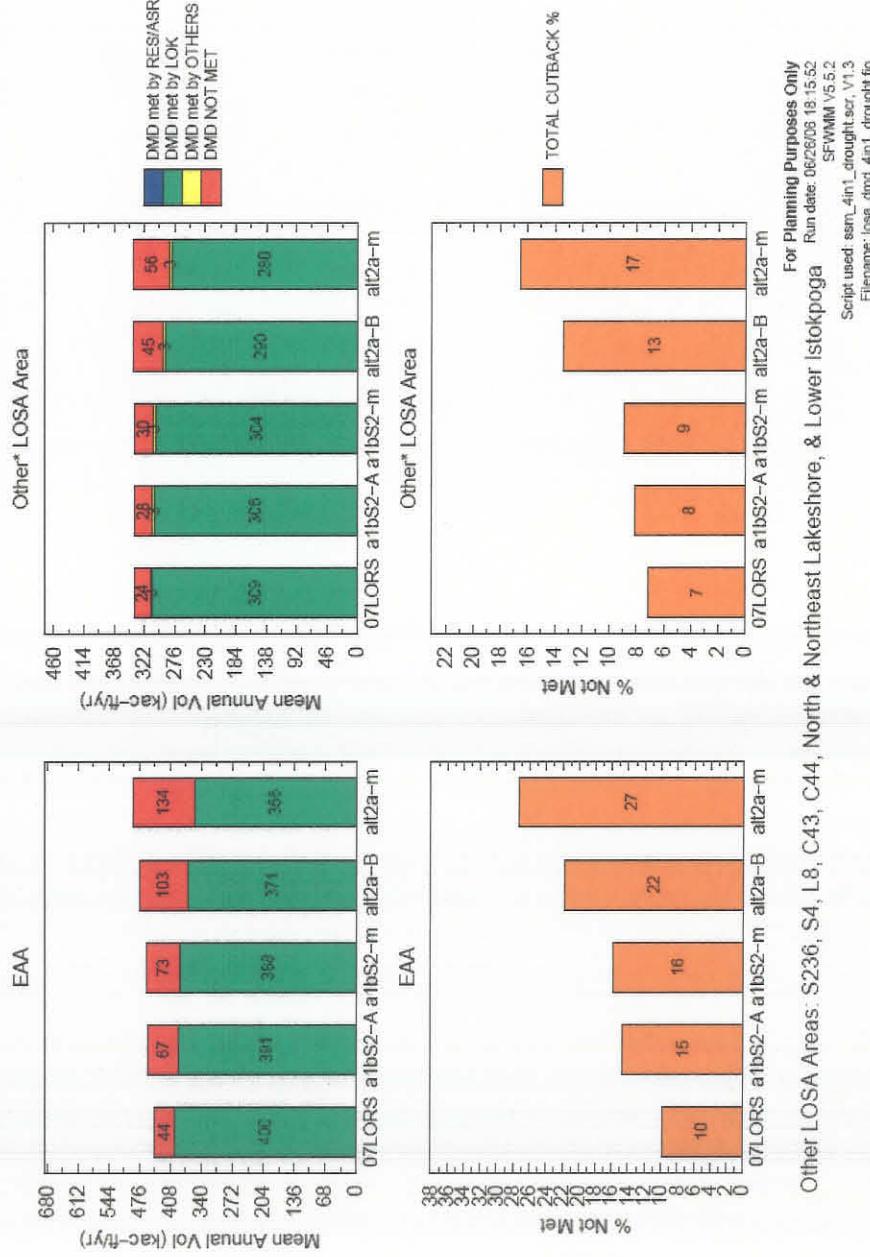


FIGURE D-27: MEAN ANNUAL EAA/LOSA SUPPLEMENTAL IRRIGATION FOR DROUGHT YEARS (1)

**Mean Annual EAA/LOSA Supplemental Irrigation:
Demands & Demands Not Met from 1965 – 2000
For Drought Years: 1971 1975 1981 1985 1989**

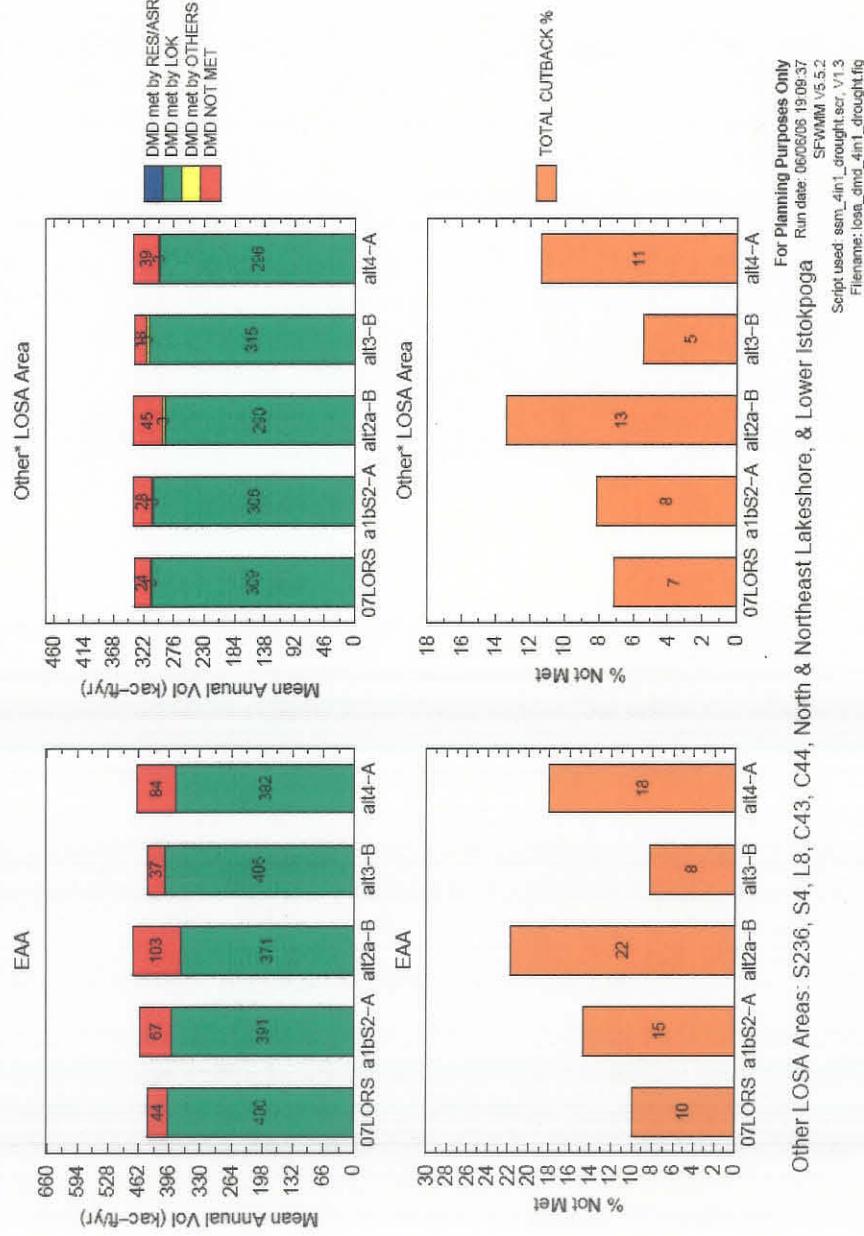


FIGURE D-28: MEAN ANNUAL EAA/LOSA SUPPLEMENTAL IRRIGATION FOR DROUGHT YEARS (2)

**Mean Annual EAA/LOSA Supplemental Irrigation:
Demands & Demands Not Met from 1965 – 2000
For Drought Years: 1971 1975 1981 1985 1989**

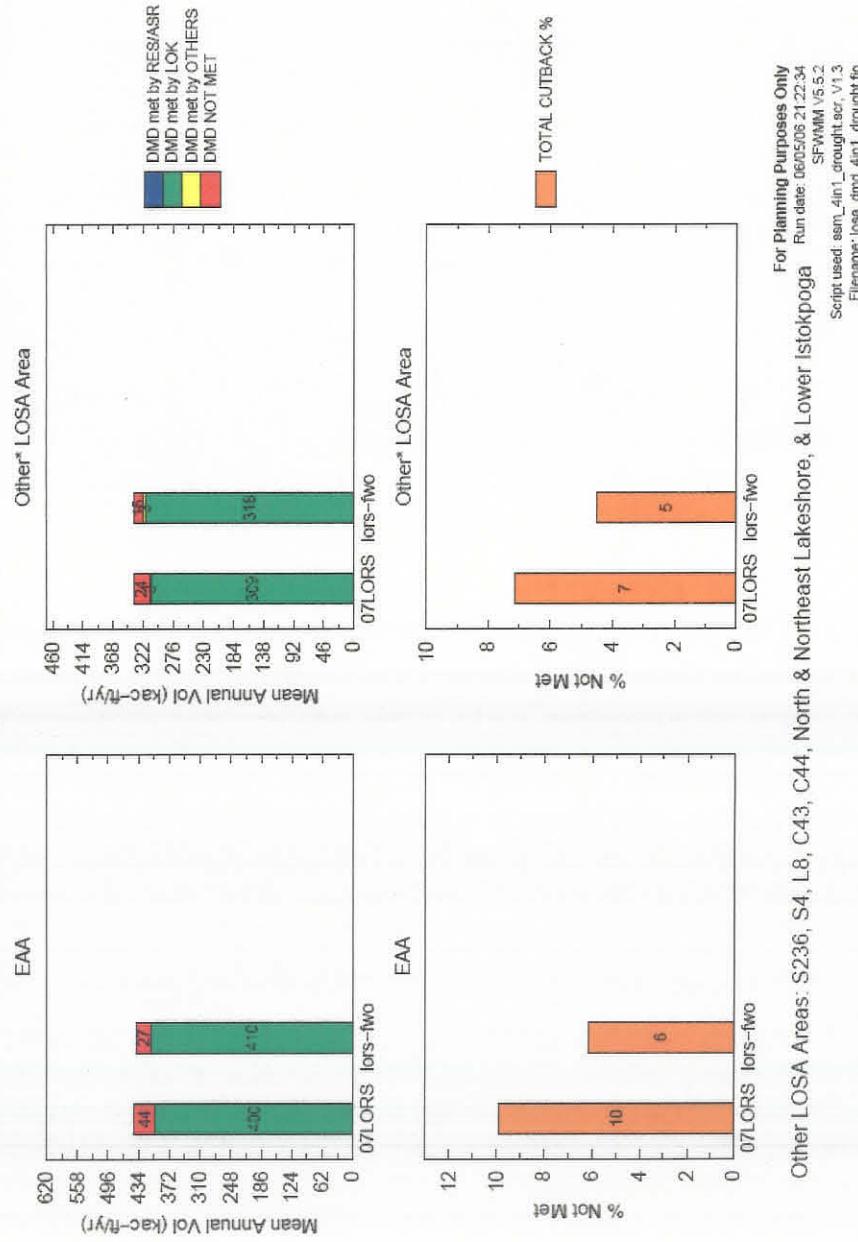


FIGURE D-29: MEAN ANNUAL EAA/LOSA SUPPLEMENTAL IRRIGATION FOR DROUGHT YEARS (3)

**Number of Months of Simulated Water Supply Cutbacks
for the 1965 – 2000 Simulation Period**

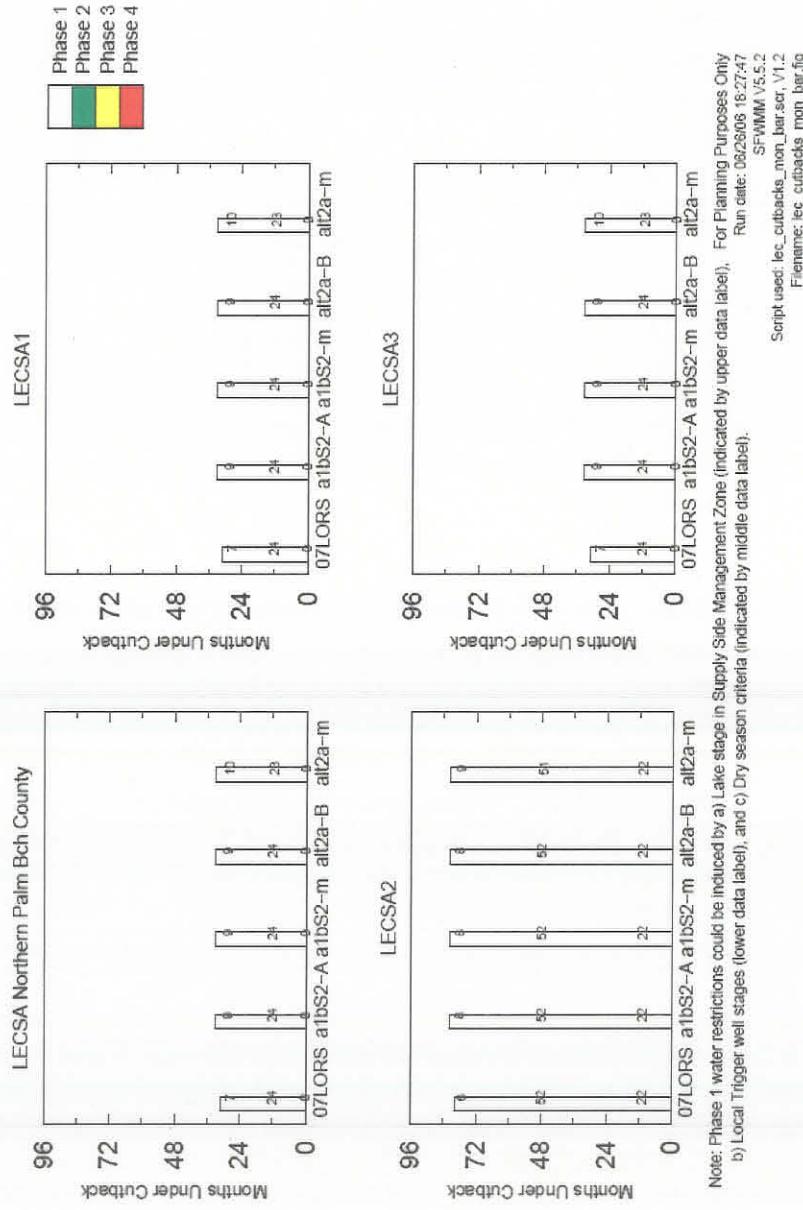


FIGURE D-30: LOWER EAST COAST SIMULATED WATER SUPPLY CUTBACKS (1)

**Number of Months of Simulated Water Supply Cutbacks
for the 1965 – 2000 Simulation Period**

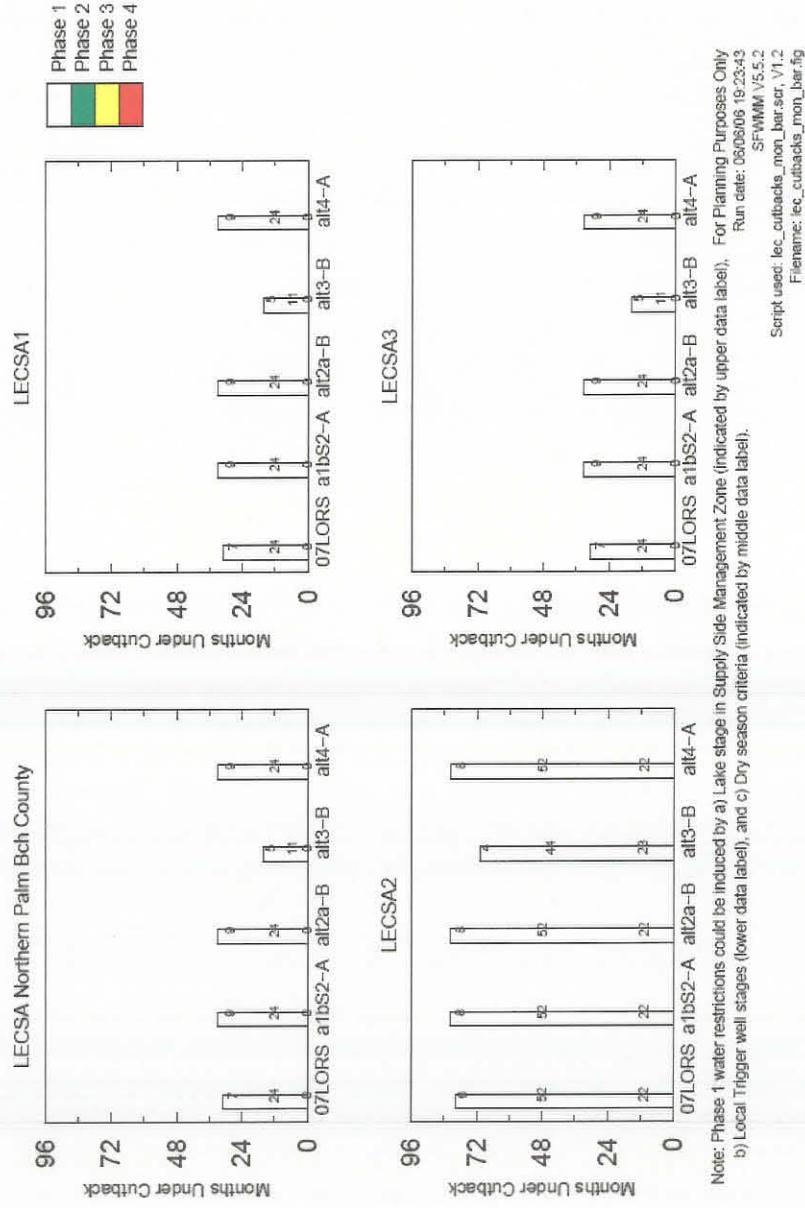


FIGURE D-31: LOWER EAST COAST SIMULATED WATER SUPPLY CUTBACKS (2)

**Number of Months of Simulated Water Supply Cutbacks
for the 1965 – 2000 Simulation Period**

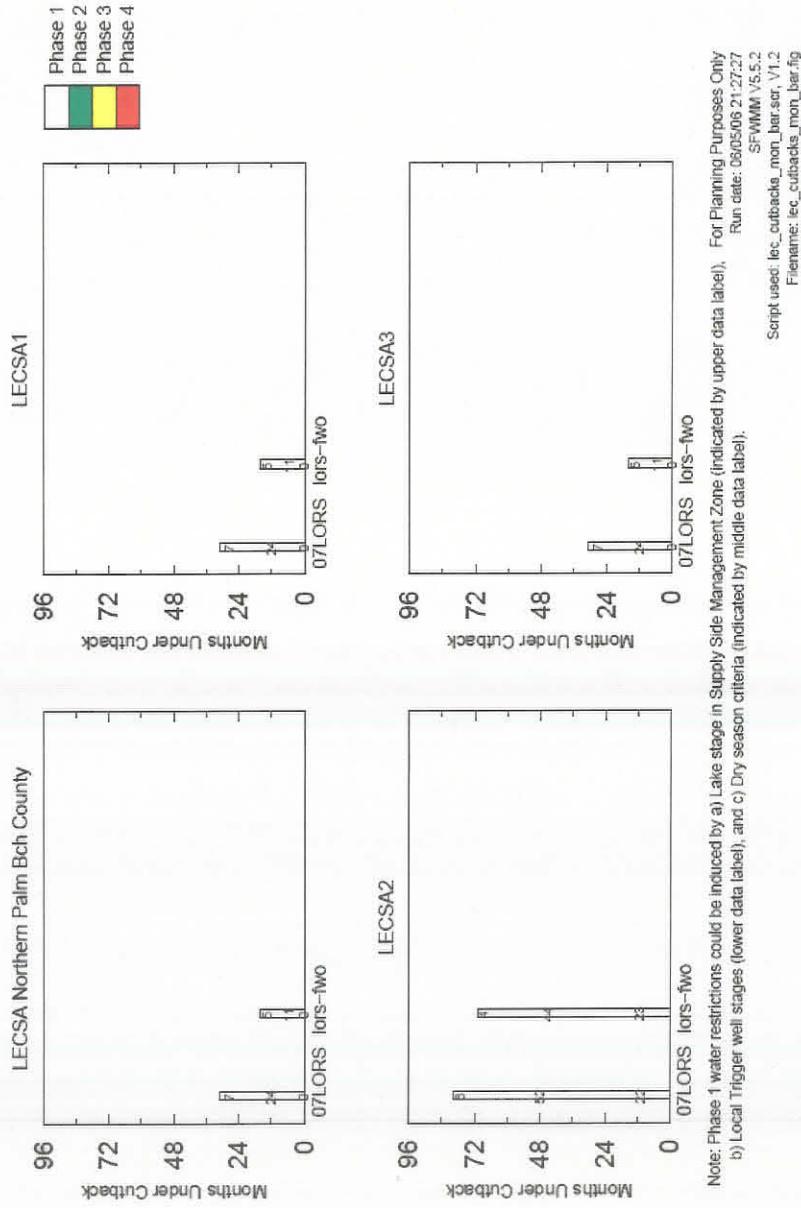


FIGURE D-32: LOWER EAST COAST SIMULATED WATER SUPPLY CUTBACKS (3)

ATTACHMENT E

Summary of Assumptions used for LORSS Baseline (No Action Alternative)

LORSS 2005 Base Condition
SFWMM Model Assumptions Table
(Based on SFWMD LEC2005 Base Condition)

Feature	Assumptions
<i>Regional Input Data</i>	
Climate	<ul style="list-style-type: none"> The climatic period of record is from 1965 to 2000. Rainfall estimates have been revised and updated for 1965-2000. Revised evapotranspiration methods have been used for 1965-2000.
Topography	<p>Updated November 2001 and September 2003 using latest available information (in NGVD 29 datum).</p> <p>November 2001 update includes:</p> <ul style="list-style-type: none"> U.S. Geological Survey (USGS) High Accuracy Elevation data from helicopter surveys collected 1999-2000 for Everglades National Park and WCA 3 south of Alligator Alley USGS Lidar data (May 1999) for WCA 3A north of Alligator Alley Lindahl, Browning, Ferrari & Helstrom 1999 survey for Rotenberger Wildlife Management Area. Storm water Treatment Area surveys from 1990s Aerometric Corp. 1986 survey of the 8-1/2 square mile area Includes estimate of Everglades Agricultural Area subsidence Other data as in SFWMM v3.7 Florida Fish and Wildlife Commission (FWC) survey 1992 for Holey Land Wildlife Management Area. <p>September 2003 update includes:</p> <ul style="list-style-type: none"> Reverting to FWC 1992 survey data for Rotenberger Wildlife Management Area. DHI gridded data from Kimley-Horn contracted survey of EAA, 2002-2003. Regridded to 2x2 scale for EAA outside of STAs and WMAs.
Sea Level	<ul style="list-style-type: none"> Sea level data from six long-term National Oceanic and Atmospheric Association (NOAA) stations were used to generate a historic record to use as sea level boundary conditions for the 1965 to 2000 evaluation period.

Feature	Assumptions
Land Use	<ul style="list-style-type: none"> • All land use has been updated using most recent Florida Land Use / Land Cover Classification System (FLUCCS) data (1995), modified in the Lower East Coast urban areas using 2000 aerial photography (2x2 scale).
Natural Area Land Cover (Vegetation)	<p>Vegetation classes and their spatial distribution in the natural areas comes from the following data:</p> <ul style="list-style-type: none"> • Walsh 1995 aerial photography in Everglades National Park • Rutcher 1995 classification in WCA 3B, WCA 3A north of Alligator Alley and the Miami Canal, WCA 2A and 2B • Richardson 1990 data for Loxahatchee National Wildlife Refuge • FLUCCS 1995 for Big Cypress National Preserve, Holey Land and Rotenberger Wildlife Management Areas, and WCA 3A south of Alligator Alley and Miami Canal.
Lake Okeechobee Service Area	
LOSA Basins	<ul style="list-style-type: none"> • Lower Istiopoga, S-4, North Lake Shore and Northeast Lake Shore demands and runoff based on AFISIRS modeling.
Lake Okeechobee	<ul style="list-style-type: none"> • Lake Okeechobee Regulation Schedule WSE according to WSE decision trees, with pulse releases in Zone D modeled as Level III pulse in upper third of the zone, Level II pulse in middle third of the zone, and Level I pulse in the lower third of the zone, when the decision tree calls for regulatory releases to the estuaries in that zone. • WSE thresholds according to the Class Limit Adjustment (CLA) for WSE: Increase the frequency of Pulse Releases in Zone D of WSE. • WSE regulatory discharges south, at times when the decision tree calls for such releases, include maximal use of discharge pathway L8 → C51 → tide, to reflect ongoing lake operations. <ul style="list-style-type: none"> • Lake Okeechobee Supply Side management policy for Lake Okeechobee Service Area water restriction cutbacks as per rule 40E-21 and 40E-22. • Emergency flood control back pumping to Lake Okeechobee from the Everglades Agricultural Area.

Feature	Assumptions
	<ul style="list-style-type: none"> Kissimmee River inflows based on interim schedule for Kissimmee Chain of Lakes using the UKISS model. Flood control releases south of Lake Okeechobee are constrained by WCA regulation schedules Only STA-3/4 would be used to treat Lake Okeechobee regulatory releases to the south
Caloosahatchee River Basin and S-4 Basins	<ul style="list-style-type: none"> Caloosahatchee River Basin irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage. Public water supply daily intake from the river is included in the analysis.
St. Lucie Canal Basin	<ul style="list-style-type: none"> St. Lucie Canal Basin demands estimated using the AFSIRS method based on existing planted acreage. Basin demands include the Florida Power & Light reservoir at Indiantown.
Seminole Brighton Reservation	<ul style="list-style-type: none"> Brighton reservation demands were estimated using AFSIRS method based on existing planted acreage in a manner consistent with that applied to other basins not in the distributed mesh of the SFWMM. The 2 in 10 demand set forth in the Seminole Compact Work plan equals 2,262 MGM (million gallons/month). AFSIRS modeled 2 in 10 demands equaled 2,383 MGM. While estimated demands, and therefore deliveries, for every month of simulation do not equate to monthly entitlement quantities as per Table 7, Agreement 41-21 (Nov. 1992), tribal rights to these quantities are preserved. SSM applies to this agreement.
Seminole Big Cypress Reservation	<ul style="list-style-type: none"> Big Cypress Reservation irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage in a manner consistent with that applied to other basins not in the distributed mesh of the SFWMM. The 2 in 10 demand set forth in the Seminole Compact Work Plan equals 2,606 MGM. AFSIRS modeled 2 in 10 demands equaled 2,659 MGM. While estimated demands, and therefore deliveries, for every month of simulation do not equate to monthly entitlement quantities as per the District's Final Order and Tribe's Resolution establishing the Big Cypress

Feature	Assumptions
	<p>Reservation entitlement, tribal rights to these quantities are preserved.</p> <ul style="list-style-type: none"> Supply-side Management SSM applies to this agreement
Seminole Hollywood Reservation	<ul style="list-style-type: none"> Hollywood Reservation demands are set forth under VI. C of the Tribal Rights Compact. Tribal sources of water supply include various bulk sale agreements with municipal service suppliers.
Everglades Agricultural Area	<ul style="list-style-type: none"> Everglades Agricultural Area irrigation demands are simulated using climatic data for the 36 year period of record and a soil moisture accounting algorithm, with parameters calibrated to match historical regional supplemental deliveries from Lake Okeechobee. SFWMM EAA runoff and irrigation demand response to rainfall was calibrated for 1984-95 and verified for 1979-1983/1996-2000. No runoff reduction adjustment was necessary to account for Best Management Practices (BMPs). EAA cells in the Miami Canal Basin between STA5 and STA6 are not production cells (shrub Land Use). Then, no irrigation demands are required in this area. Runoff from this area is part of the Miami Canal Basin.
Everglades Construction Project Stormwater Treatment Areas	<ul style="list-style-type: none"> Storm water Treatment Area 2 is connected to the regional system and operational. STA-2 all three cells operational (6,430 acres on line) STA 1E is built and in place, but not operational. STA-1W is partially operational with approximately 5,371 acres on line STA-5 is partially operational with approximately 2,890 acres on line STA-6 Section 1 operational with 897 acres on line STA-3/4 is partially operational with approximately 11,000 acres on line Operation of Storm water Treatment Areas assumes maintenance of a 6" minimum depth.
Holey Land Wildlife WMA	<ul style="list-style-type: none"> As per Memorandum of Agreement between the FWC and the South Florida Water Management District.

Feature	Assumptions
Rotenberger Wildlife WMA	<ul style="list-style-type: none"> • Interim Operational Schedule as defined in the Operation Plan for Rotenberger, 2001.
Water Conservation Areas	
WCA 1 (Arthur R Mitchell [ARM] Loxahatchee National Wildlife Refuge)	<ul style="list-style-type: none"> • Current Central and Southern Florida (C&SF) Regulation Schedule. Includes regulatory releases to tide through LEC canals. • No net outflow to maintain minimum stages in the LEC/SA canals (salinity control), if water levels are less than minimum operating criteria of 14 feet. The bottom floor of the schedule (Zone C) is the area below 14 feet. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
WCA 2 A&B	<ul style="list-style-type: none"> • Current C&SF regulation schedule. Includes regulatory releases to tide through LEC canals. • No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels in WCA 2A are less than minimum operating criteria of 10.5 feet. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
WCA 3 A&B	<ul style="list-style-type: none"> • Current C&SF regulation schedule for WCA 3A, as per WCP-IOP for protection of the Cape Sable seaside sparrow-C&SF Project for Flood Control and other Purposes, 2002. • Includes regulatory releases to tide through LEC canals. Documented in WCP, 2002. • No net outflow to maintain minimum stages in the LEC/SA canals (salinity control), if water levels are less than minimum operating criteria of 7.5 feet in WCA 3A. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
Lower East Coast Service Areas	
Public Water Supply and Irrigation	<ul style="list-style-type: none"> • Public water supply wellfield pumpages and locations are based on actual pumpage data for calendar year 2004. • Irrigation demands are based upon existing land use (updated through 2000) and calculated using AFSIRS, reduced to account for landscape and golf course areas irrigated using reuse water and landscape areas

Feature	Assumptions
Other Natural Areas	<ul style="list-style-type: none"> • irrigated using public water supply. <ul style="list-style-type: none"> • For the Northwest Fork of the Loxahatchee River, the District operates the G-92 structure and associated structures to provide approximately 50 cfs over Lainhart Dam to the Northwest Fork, when sufficient water is available in C-18 Canal. • Flows to Pond Apple Slough through S-13A are adjusted in the model to approximate measured flows at the structure. • Flows to Biscayne Bay are simulated through Snake Creek, North Bay, the Miami River, Central Bay and South Bay.
Coastal Basin Canal Facilities and Operations	<ul style="list-style-type: none"> • C&SF system and operating rules in effect in 2005. • Includes operations to meet control elevations in the primary coastal canals for the prevention of saltwater intrusion. • Includes existing secondary drainage/water supply system. • C-4 Flood Mitigation Project • C-11 Water Quality Treatment Critical Project (S-381 and S-9A) • Releases from WCA 3A to ENP and the South Dade Conveyance System (SDCS) will follow the IOP: <ul style="list-style-type: none"> ○ Decreased S-12 flood control discharges and increased flood control discharges to SDCS Structures S-343A, S-343B, S-344 and S-12A are closed Nov. 1 to July 15 ○ Structure S-12B is closed Jan. 1 to July 15. ○ Structure S-12C is closed Feb. 1 to July 15. ○ South Dade Conveyance System operations will follow IOP for protection of the Cape Sable seaside sparrow
Western Basins and Big Cypress National Preserve	<ul style="list-style-type: none"> • Estimated and updated historical inflows from western basins at two locations: G-136 and G-406. The G-406 location represents potential inflow from the C-139 Basin into STA 5. Data for the period 1978-2000

Feature	Assumptions
	is the same as the data used for the C-139 Basin Rule development.
Big Cypress National Preserve	<ul style="list-style-type: none"> • Simulated demands in excess of historical demands are partially supply by basin flows. Any remaining excess water is directed to S-190. • Tamiami Trail culverts are not modeled in SFWMM due to the coarse (2x2 mile) model resolution
<i>Everglades National Park and Florida Bay</i>	
Everglades National Park	<ul style="list-style-type: none"> • Water deliveries to Everglades National Park are based upon the IOP. • When stages in WCA 3A fall in Zone E1 of the regulation schedule and the stage at G-3273 is below the critical threshold, S-333 flows are directed to ENP, a fraction of which is released through S334. This simulation is consistent with IOP ALT7RP2.
<i>Region-wide Water Management and Related Operations</i>	
Water Shortage Rules	<ul style="list-style-type: none"> • The existing condition reflects the existing water shortage policies in 2005 as reflected in SFWMD Chapters 40E-21 and 40E-22, FAC

APPENDIX F

Incorporation of a Periodic Managed Recession Lake Okeechobee, Florida



**Prepared by the
South Florida Water Management District**

November 2007

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Incorporation of Periodic Managed Recessions into the TSP

Background

The hurricanes of 2004 and 2005 devastated the submerged aquatic vegetation (SAV) community in Lake Okeechobee, significantly degrading the lake's health. SAV stabilizes the fine, nutrient-laden sediments; reduces phosphorus concentrations in the water; increases water column oxygenation; and provides habitat for fish and other aquatic organisms. Experience gained from the managed recession (MR) and drought of 2000-2001 and the low summer lake stages of 2006 as well as reports in the scientific literature suggest that managed recessions have the potential to stimulate regrowth of SAV if a viable seed bank and suitable water quality exist. Re-growth of SAV typically improves overall lake health. This potential for improvement has produced requests to have the LORS DEIS acknowledge the future potential need for infrequent periodic managed recessions to preserve this critical component of the lake ecosystem and have them included in the new lake regulation schedule.

The LORSS TSP will significantly reduce the sustained high water conditions that lead to the need for a managed recession. Nevertheless, conditions may arise where this action is considered necessary, so authorizing its use in this EIS is important. It is important to recognize, as was apparent when the first managed recession was implemented in 2000, that forecasting future climate conditions is not possible. Therefore, unless the lake's SAV community has been excessively damaged by hurricanes or other exceptional conditions that require immediate action, no managed recession will be attempted unless the stage/time window of 12 weeks below a stage of 12 feet during the SAV growing season has not occurred during the preceding four years. In addition, due to concerns about apple snails in the interior marsh, and consequent effects on the snail kite, no more than a single 2 consecutive year recession in any 8 year period (thus no more than 1 recession occurring during the anticipated life of this schedule revision).

The decision to implement a managed recession will be contingent on several factors, including climatic conditions and lake health. These factors will include determining:

- Whether a viable seed bank is present.
- The chance of reaching the stage target of 12' by April 15 for a minimum of 12 weeks.
- Whether attempting to reach the stage target will adversely affect other ecosystems.
- Potential impacts to the Herbert Hoover Dike from low lake stages.
- Once committed to a managed recession, what lake stage thresholds would be cause for abandoning the attempt
- Changes in average salinity regimes due to lake discharges to the downstream estuaries;

- Increased phosphorus loading from lake discharges to the STAs and the Everglades; and
- The risk of reduced water supply for agricultural, utilities, and the natural environment if conditions following the recession became drier than expected (Steinman et al. 2002).

Conditions

- If by early November of any year, it is determined that the conditions are favorable to implement a managed recession, then an analysis similar to the preliminary analysis contained in this report will be conducted to determine the range of possible impacts.
- A Position Analysis (PA), defined below, will be the basis of the proposed operations to determine the chance of meeting the recession target of 12 feet by April 15th of the following year. The 12' for 12 weeks alternative schedule (Figure XX) corresponds to the peak SAV growing season, when chances are best to restore a healthy SAV population.
- For the preliminary analysis below, the proposed Lake Okeechobee Water Supply Management (LOWSM) Plan was included, and the temporary forward pumps were assumed to be available to deliver water supplies at low lake stages, for both the TSP and the Managed Recession model runs.
- A PA is a projection of possible lake stages and discharges from a set point in time; simulations are typically used for short-term (<6 months) projections
 - PA simulations are 36 consecutive 1-yr simulations, differing from the period-of-record continuous simulations with the SFWM (one 36-yr simulation);
 - Each 1-yr simulation:
 - starts with the same initial condition
 - is driven by historical rainfall data
 - represents one prediction of what could happen in the future
 - Outputs are typically reported using probabilities

The decision tree in Figure X summarizes the planning process that would be considered for any future periodic recession. Experience gained in the 2000-2001 drawdown and drought led to the target of 12' or below lake stage for 12 weeks from April through June for the best SAV recovery. Experience also indicates that the decision making process should begin with the November 1st position analysis. Contributing decision factors are lake bathymetry, Minimum Flows and Levels (MFL), as well as the time it took for a measurable SAV response to occur in 2000.

Analysis Methodology

If conditions require consideration of a managed recession, then further analysis similar to that presented here would be performed to evaluate the potential benefits and impacts. The analysis presented in this document is based on a simulation of three initial lake stage conditions: High or Wet (16.0' NGVD), Average or Normal (14.0' NGVD) and Low or Dry Condition (12.5' NGVD). Low, average and high refer to the canal and groundwater levels selected for initial conditions at the beginning of each dry Season: low = November 1, 1987, average = November 1, 1965, and high = November 1, 1982. Six simulations will be run for the two alternatives: three initial conditions for the official regulation schedule (aka TSP) and three for the base with the Managed Recession target of approximately 12' for 12 weeks.

A preliminary analysis of the projected benefits and impacts of the TSP with a managed recession were quantified using the following set of performance measures;

1. Lake Okeechobee
 - a. Chance of achieving the target Lake stage/time window of 12' or below for 12 consecutive weeks during the peak SAV growing season.
2. Caloosahatchee and St. Lucie Estuaries
 - a. Percent of time with damaging low salinity (salinity below the lower limit of the salinity envelope)
3. Lake Okeechobee Service Area (LOSA) Water Supply
 - a. Chance (% of years) of water use cutbacks
4. Everglades
 - a. Peat dryout
 - b. Tree island inundation

Performance Measure Evaluations

Lake Okeechobee Performance

The potential for achieving a managed recession is best when the lake stage is less than 14' on November 1st, and the probability of success decreases as lake stage on that date increases towards 16'. It should not be the risk determined by the probability alone that determines whether to proceed with a recession, but many other factors, including the degree of ecological necessity. Although the ideal recession reaches a lake stage of 12' and maintains it from mid April to mid July, decision analysis should not discount recessions achieving stage elevations of up to 12.5' shifted either slightly forward or slightly backward in time. However, the 12 week duration should remain fixed, based on our experience of the length of time required to obtain a positive SAV response.

Chance of Achieving the Stage Target		
(Percent chance that the lake stage remains at 12 ft. NGVD for at least 12 consecutive weeks)		
01- Nov initial stage condition	TSP	Managed Recession
Low (12.5')	51	60
Average (14.0')	37	40
High (16.0')	6	17

Water Supply Performance

Water supply performance for the TSP and Managed Recession alternatives was evaluated by considering the frequency of water shortages in the Lake Okeechobee Service Area. The simulations covered 35 full water years (November to October), and years with one or more months with cutbacks greater than 18,000 acre feet were counted as water shortage years. The 18,000 acre feet is a criterion used in CERP evaluations. The summary below shows that while the starting lake level has a significant influence on the likelihood of water shortages, the operations under the managed recession criteria have only a small or no impact on this likelihood.

Frequency of Water Shortages in the Lake Okeechobee Service Area*		
(Percents)		
01- Nov initial stage condition	TSP	Managed Recession
Low (12.5')	22.9%	28.6%
Average (14.0')	8.6%	8.6%
High (16.0')	2.9%	5.7%

* Percent of years out of the 35 complete water years simulated. Years with one or more months with cutbacks greater than 18,000 acre feet were counted as water shortage years.

Estuarine Performance

Effects of a Lake Okeechobee managed recession on the Caloosahatchee and St. Lucie Estuaries were evaluated using regression models that related freshwater discharge to salinity at critical locations in each system. Effects were quantified by comparing results from the Tentatively Selected Plan (TSP) with the proposed MR commencing on November 1. The SFWMM output consisted of a 35 year (Nov 1, 1965 to Oct 31, 2000) record of daily discharge at S-79 on the West Coast and at S-80 on the East Coast.

Methods and Assumptions:

St. Lucie Estuary:

Discharge from the C-44 canal at S-80 is only part of the total surface water discharge to the St. Lucie estuary. Estimates of runoff from basins other than C-44 were added to the SFWMM output at S-80 to derive a total daily inflow to the St. Lucie estuary for each of the six alternatives. Using two different regression models, daily average salinity at the Roosevelt and A1A Bridges was estimated from the 35 1-yr simulations.

A preferred salinity envelope has been previously developed for each site based on the requirements of the eastern oyster, *Crassostrea virginica*. The salinity envelope for the Roosevelt Bridge is 8 to 25 ppt. The envelope for the A1A Bridge is 20 to 31 ppt. Results were expressed as average annual number of days that salinity was above or below the salinity envelope at the two sites.

Caloosahatchee Estuary:

The discharge at structure S-79 is only part of the runoff entering the Caloosahatchee Estuary. A significant portion enters from the tidal basin, downstream of the structure. The discharge from Tidal Caloosahatchee Basin was estimated and added to the SFWMM output at S79 to derive a total daily inflow to the estuary. The tidal basin runoff calculation was based on the median value of a 30-year record generated by linear reservoir model driven by rainfall and evaporation (Konyha, 2002, Peterson, 2002).

Using separate regression models, the combined flow to the Caloosahatchee was converted to salinity at three locations: Ft. Myers, Iona Cove and the Sanibel causeway. The results are presented as the annual average number of days that salinity at Ft. Myers was above 10 ppt; below 12 ppt in Iona Cove (station H4) and below 25 ppt at the Sanibel Causeway. These threshold values are based on the salinity tolerances of various species of SAV. In the upper estuary near Ft. Myers the freshwater species, *Vallisneria americana*, prefers salinities below 10 ppt. In Iona Cove, shoal grass, *Halodule wrightii*, will be stressed when salinity falls below 12 ppt. Similarly, salinities below 25 ppt at Sanibel will stress turtle grass, *Thalassia testudinum*, in San Carlos Bay.

The salinity analysis indicates that the most opportune time for a managed recession is when the lake is relatively low on Nov. 1. An analysis of mean monthly

flows to the Caloosahatchee indicates that the number of months of high (>2800 cfs) flows occurring during a MRLow condition (60 months) does not exceed the number occurring during the average condition experienced under TSP3 (TSPAvg = 60 months). Therefore, the adverse conditions due to high flows under the MRLow conditions are equivalent to those experienced by the Caloosahatchee during an average year of operations under TSP3.

Results:

St. Lucie Estuary:

Number of Days (Average Annual)	Roosevelt Bridge (< 8 ppt)	Roosevelt Bridge (>25 ppt)	A1A Bridge <th>A1A Bridge<br (>25="" ppt)<="" th=""/></th>	A1A Bridge
TSP Low	49	110	61	101
MR Low	57	108	69	99
%Diff (mr-tsp)/tsp	16.0	-1.4	14.0	-1.6
TSP Avg	60	85	72	79
MR Avg	71	84	83	77
%Diff (mr-tsp)/tsp	18.3	-2.1	15.6	-2.8
TSP High	79	72	92	66
MR High	101	68	111	62
%Diff (mr-tsp)/tsp	28.4	-6.1	21.8	-6.0

A Managed Recession necessitates releases from the Lake above and beyond what would occur under normal operating procedures. Regardless of the Lake's initial stage, the Managed Recession increased the number of days below the lower limit of the salinity envelope at both sites. Conversely, the number of days above the salinity envelope decreased. Salinities below 8 ppt will cause stress and eventual mortality of juvenile oysters after about 7 days and adults after 14 days. The managed recession increased the number of days by 8 days (low), 11 days (avg) and 22 days (high). Considering these differences as consecutive days of exposure, low or average stage MRs would not significantly increase mortality of adult oysters, but the high stage MR would cause significant mortality. All managed recessions would affect juvenile oysters with the severity increasing as the initial Lake stage of the MR increased.

Caloosahatchee Estuary:

Number of days (total 12784 days)	Daily salinity at Ft. Myers>10 ppt	Daily salinity at Iona Cove<12 ppt	Daily salinity at Sanibel<25 ppt	Number of days (total 12784 days)
TSP low	207	58	30	TSP low
MR low	199	67	37	MR low
% Diff (mr-tsp)/tsp	-4.3	17.0	23.0	% Diff (mr-tsp)/tsp
TSP average	187	67	36	TSP average
MR average	173	80	49	MR average
% Diff (mr-tsp)/tsp	-7.5	19.0	39.0	% Diff (mr-tsp)/tsp
TSP high	155	91	53	TSP high
MR high	127	119	79	MR high
% Diff (mr-tsp)/tsp	-18.0	30.6	49.8	% Diff (mr-tsp)/tsp

Caloosahatchee	Mean Monthly Flows at S-79: Number of Months in each Class			
Alternative	<450 cfs	450 – 2800 cfs	2800 – 4500 cfs	> 4500
TSP Low	226	158	32	16
MRLow	217	155	35	25
TSPAvg	213	159	35	25
MRAvg	189	166	38	39
TSPHigh	160	180	48	44
MRHigh	124	177	75	56

All MR scenarios decreased the number of days that salinity exceeded 10 ppt in the upper estuary. Therefore, none of the MR scenarios increased stress of *Vallisneria* in the upper estuary relative to normal operations under the TSP. In fact, the higher the initial Lake stage, the better salinity conditions become in the upper estuary because the amount of water released from the lake increases as the MR stage increases.

Salinity effects of an MR will be felt in the lower estuary and San Carlos Bay where marine seagrasses are found. During a low Lake stage MR, the number of days of stressful salinity range from 7 to 9 depending on location. This is unlikely to cause ecologically significant damage. Stress for marine seagrasses increases by an average of nearly two weeks per year when MRs begin at an average Lake stage and by nearly a month when Lake stages are high. The latter situation may result in significant mortality.

Discussion and Conclusion:

Analysis of the data suggests that the most opportune time for a MR is when initial Lake stages are low. The most inopportune time is when they are high. As indicated by results for the St. Lucie, MRs that begin at average Lake stages may affect the more sensitive stages of indicator species, while more tolerant live stages may survive.

Greater Everglades Performance

Indicator Regions representing a variety of habitat types in the Everglades were used to compare the hydrologic performances of the Managed Recessions relative to the Tentatively Selected Plan. The Indicator Regions (IR's) represent subsets of the major Everglades ecosystems with differing hydrologic and ecological conditions, ranging from the southern end of the Everglades Agricultural Area (EAA) through the conservation areas to the southern tip of the Everglades National Park (see Fig. X).

Hydrologic Performance Measures were used in these analyses to evaluate impacts of the Managed Recessions under low, average, and high water conditions. Water quality was not evaluated. The Everglades Performance Measures were 1) peat dry-out and 2) tree island inundation, the two ends of the spectrum regarding water depths. Thirty-six areas were evaluated. For each Indicator Region, the number of weeks that the water table fell a foot or more below the surface or that water depths were above those deemed appropriate for tree island vegetation to survive and thrive were recorded. The model simulations produced values for the tentatively selected plan and for that plan with the managed recessions factored in. The following results report the differences between those sets of comparisons (low TSP vs. low TSP with managed recessions).

Peat Dryout

Under managed recession conditions, peat dryout did not change in any ecologically significant ways in the WCA Indicator regions under either the low or average scenarios (only two weeks or less for the 36-year period of simulation).

However, under the high water scenarios, large differences between the TSP and the Managed Recession scenarios were seen in the southern Everglades, producing a net decrease of 114 weeks (3.8%) of high water levels for the Everglades overall. Other than these changes in the southern Everglades, differences between the TSP and MR in the Water Conservation Areas were very small. A decrease in the number of weeks of dryout is an improvement to the ecosystems of the Everglades. Therefore, the Managed Recession scenario for high water conditions represents a net improvement of 114 weeks over the TSP.

The reductions in dryout were largest in Indicator Regions 141, 142, 147, and 148, which are in the Ochopee Marl Marsh west of Shark River Slough and the Rocky

Glades east of Shark River Slough. In these four Indicator Regions, the Managed Recession scenarios reduced the number of weeks in quantities that provide ecologically significant improvements (total weeks and percent change).

Below is a table that summarizes the number of weeks and the percent differences they represent for the four southern Indicator Regions:

Table 1. Comparisons of TSP and the Managed Recession scenarios under high water conditions for Indicator Regions showing significant changes. Decreases in dryout duration and frequency are considered an improvement.

Indicator Region	TSP_high	MR_high	Dif.	% dif
Number	weeks	weeks	weeks	(MR-TSP)
141	173	159	-14	-8.09%
142	250	229	-21	-8.40%
147	305	272	-33	-10.82%
148	207	181	-26	-12.56%

Tree Island Inundation

As with the peat dryout, only a few of the Indicator Regions changed significantly under the Managed Recession scenarios. These changes were increases in the number of weeks that tree islands would be inundated, and of these, only two were in areas that experience excess inundation at present. For low and average water conditions, the differences between the TSP and the MR scenario do not appear to be ecologically significant. The high water scenarios produced significant increases in two Indicator Regions (119 and 124) in the southern areas of WCA-3. These areas experience water depths great enough to harm tree island vegetation now, so an increase in duration or depths in these two IR's would not be preferred. The other two IRs (116 and 118) are located in the northern and central section of WCA-3A, where water depths are not harmful to tree islands, so in these areas, higher water or longer duration would probably not cause additional harm to tree island vegetation.

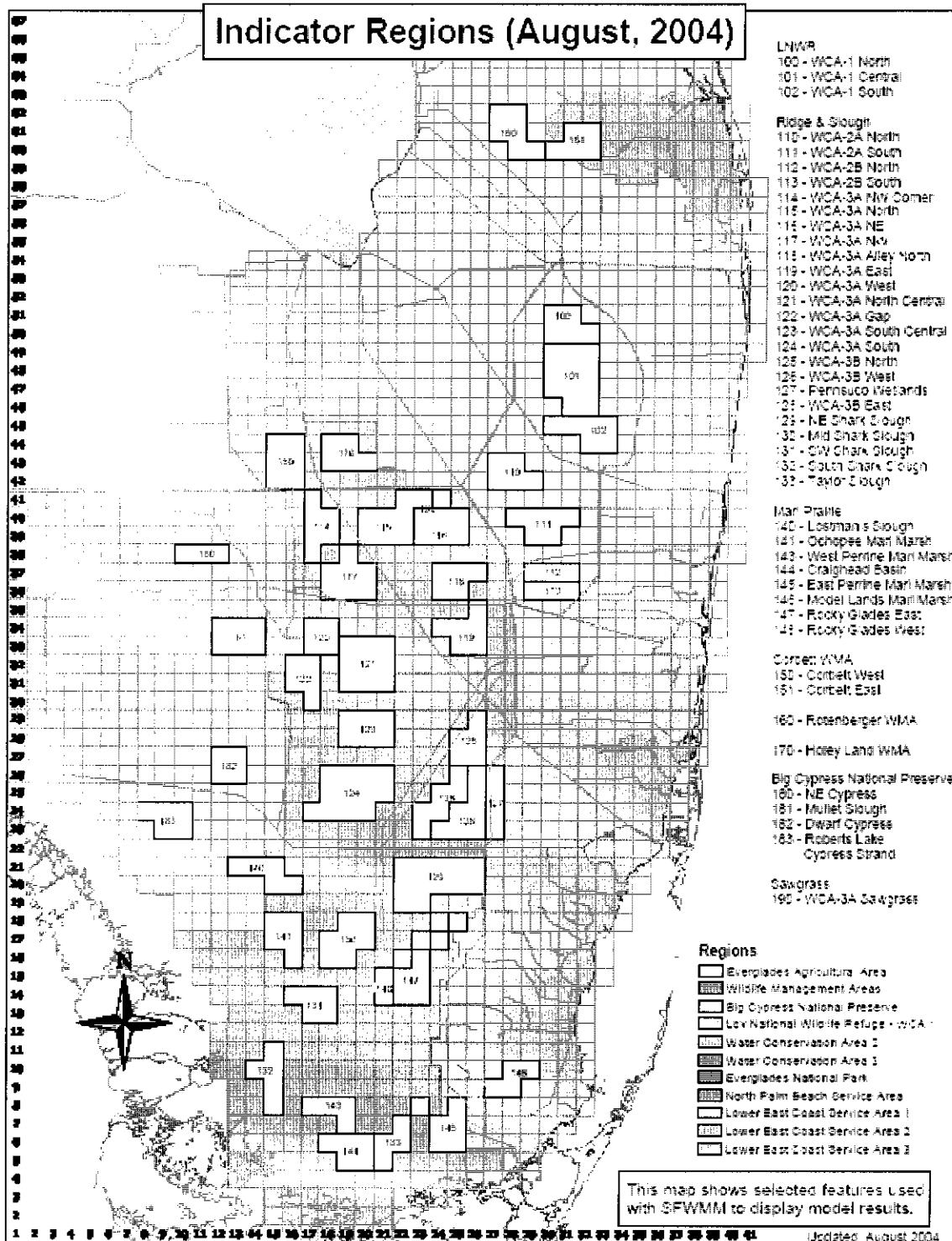
Below is a table that summarizes the number of weeks and the percent differences they represent for the four WCA-3 Indicator Regions:

Table 2. Comparisons of TSP and the Managed Recession scenarios under high water conditions for Indicator Regions showing significant changes. Increases in inundation duration and frequency may harm tree islands in IR's 119 and 124 because of their location with current high water depths.

Indicator Region	TSP_high	MR_high	Dif.	% dif
Number	weeks	weeks	(MR-TSP)	(MR-TSP)
116	130	138	8	6.2%
118	154	163	9	5.8%
119	1167	1203	36	3.1%
124	592	632	40	6.8%

In summary, negative impacts on the Everglades from the Managed Recession water management are restricted to a few indicator regions under only the high water scenarios. Increases in water depths or duration may be harmful for IR's 119 and 124 in WCA-3. However, for peat dryout, the southern Everglades would show improvement under the Managed Recession conditions along the edges of Shark River Slough.

Figure X Indicator Regions for Greater Everglades Performance Measures.



Overall Performance Summary Table

Based on the above performance measure evaluations, the managed recession has a better chance of success when the November 1 stage (initial condition) is relatively low (12.5') or relatively high (16.0') but chances of success are probably not worth the effort for the average (14.0') initial conditions. Adverse impacts to all other areas are significant for the high initial conditions. But for the low initial conditions, the adverse impacts apply to water supply and possibly navigation, which is not presented here. It appears that a successful managed recession would be achieved only in an exceptionally dry year without additional releases to the estuaries.

Initial Conditions on 01-Nov	Lake Okeechobee	Estuaries	Water Supply (& navigation)	Everglades
High (16.0')	+	-	-	-
Average (14.0')	+	- / 0	0	0
Low (12.5')	+	0	-	0

Managed Recession Effects (+ good, 0 neutral, - bad)

(The following section may be more relevant in an appendix, exclusive of the 2 graphics at the end, which need to stay in the body of the above summary)

Benefits of the 2000 Managed Recession

The SFWMD has documented that seven of the nine years between 1991 and 1999 resulted in high lake stages and impacted the ecology of Lake Okeechobee by allowing less light to reach the bottom of the lake, resulting in the loss of submerged vegetation. Increased turbidity levels may have also resulted in light limitation of bulrush (*Scirpus* sp.), which in turn may have weakened the plants, making them more susceptible to uprooting by wind-driven waves (Steinman et al. 2002). The combination of high lake stages and wind driven waves likewise resulted in an increase in phosphorus concentrations in the nearshore regions, as phosphorus-rich sediments were transported from the central mud zone toward the littoral zone, which may have favored algal bloom formation; further reducing the light available for the growth of SAV (Havens and James 1999).

The loss of SAV threatened the survival of a multi-million dollar sport fishery, which previously had been documented to rely on this habitat as spawning and nursery grounds (Furse and Fox 1994). Thus, the decision to lower the water level in Lake Okeechobee was driven by a combination of political and environmental factors (Steinman et al. 2002).

Implementation of the 2000 Managed Recession

In 2000, the Governing Board of the SFWMD adopted Resolution No. 00-31, SFWMD 2000). Although this plan had the greatest potential to meet the desired ecological outcome for Lake Okeechobee, it also had the highest risk for impacting the estuaries, the Everglades, and water users surrounding and depending on the lake. As a consequence, the potential risks and adversity were shared among the stakeholders. Resolution No. 00-31 was implemented immediately after adoption. Commencing on April 25, 2000 discharges to the east, west, and south continued for 27 days, until May 21, 2000, at which point a lake stage of 13 ft had been attained and releases from the lake were terminated.

Results

Hydrology. The hydrologic goal of lowering water levels in Lake Okeechobee to 13.0 ft was met on 21 May 2000, 10 days earlier than anticipated, due to the extremely dry conditions during the recession. The additional goal of maintaining water level at or below 13.0 ft for 8 weeks also was met, as summer 2000 was one of the driest on record in South Florida. The loss of water directly attributable to the managed recession was estimated to be approximately 1 ft, with evapotranspiration accounting for the additional lost water. Lake levels continued to drop through the summer, as areas north of the Lake experienced a severe hydrologic drought and provided no inflow.

Lake Okeechobee. Over the course of the summer of 2000, transparency in the water column increased from 0.08 - 0.12 in to near 3.3 ft (near bottom) and phosphorus concentrations declined from about 60–70 µg/L to near 20–30 µg/L, in regions where SAV recovered (Havens et al. 2001). The number of sites with SAV increased from two (of 42) in April 2000 (just prior to the managed recession) to 23 sites in August 2000. Low lake stages also allowed for the removal of an organic berm that had formed along the NW shore of the littoral zone. Over 5.5 miles of mostly organic debris, which accumulated from years of high lake stages, was mechanically removed by earth-moving equipment and consolidated by the FFWCC into several wildlife islands in the lake.

A lake survey was conducted in October 2000 for presence-absence of SAV (Havens et al. 2002). Based on this survey, it was estimated that SAV covered > 42,000 ac in Lake Okeechobee. This is similar to the spatial extent documented in a survey of the SAV in 1989–1991, coincident with another severe drought and low lake stage (Zimba et al. 1995). Although a comparable survey was not conducted prior to the managed recession in 2000, SAV cover in October 1999 was no more than 30,000 ac. Additional environmental responses to the recession can be found in Havens et al. (2001) and Steinman et al. (2002).

Additional support for the 12' for 12 weeks recommendation is evident in Figure X. Post-recession SAV monitoring indicated that after eight weeks, more than 60% of monitoring sites still lacked detectable vegetation while after 10 weeks, the percent of non-vegetated sites had decreased to less than 40%.

Monitoring of invasive species during and after the drought suggests that torpedograss expanded its cover at an accelerated rate in the littoral zone of Lake Okeechobee. Sampling of plant densities in reference plots that had been monitored since 1999 indicated that during the drought period, the rate of expansion of torpedograss increased by two- to three-fold. However, the drought also provided dry conditions that allowed the SFWMD and coordinating agencies to carry out controlled fires and treatments of torpedograss with herbicide. These treatments continued through 2001, and as of July 2002, treated areas were not displaying significant regrowth of torpedograss.

Estuaries. Monitoring conducted as part of the managed recession revealed results consistent with prior research at the SFWMD, which indicated that short-term releases of water can have immediate negative impacts, but that these systems are resilient (Doering et al. 1999, Kraemer et al. 1999). Once discharges to the St. Lucie Estuary ceased, turbidity subsided within four days and salinity returned to ranges tolerable to oysters within one week. Impacts to seagrasses along the Atlantic coastline were localized and did not persist past June 2000. Recovery of environmental conditions was slower in the Caloosahatchee Estuary because there was seagrass mortality in the lower estuary. A cyanobacterial bloom (*Anabaena* spp.) was documented in the upper estuary, presumably related to the recession operation. A working hypothesis is that the water from Lake Okeechobee “seeded” the estuary with cyanobacteria, which then proliferated to bloom levels in a subsequent period when flow was maintained at near 300 cfs for a number of weeks, keeping conditions oligohaline. This low flow rate maintained an isohaline front

near the city of Fort Myers. The bloom ended when freshwater discharges were stopped and salinity levels began to increase. However, the Caloosahatchee estuary also showed blue green algal bloom activity during the summer of 2006 when there was virtually no flow from Lake Okeechobee to the river.

Everglades. Impacts of the managed recession on the Everglades were minimal. There was no apparent impact on tree islands as a result of recession related discharges. In addition, the year 2000 turned out to be one of the most successful nesting seasons in several decades for wading birds in the Everglades as a whole (SFWMD 2001). Because the managed recession took place late in the spring, much of the nesting season was already completed and not impacted by the releases. Flow sampling during the recession revealed that relatively little canal-to-marsh water exchange occurred, because many of the marsh water levels were below land surface. There were no apparent water quality impacts, as determined from phosphorus sampling in the marshes and canals during the course of the recession.

Water Supply. Contrary to pre-recession model predictions, the region experienced a serious drought, and severe water restrictions were imposed on all water users throughout South Florida. This ranged from substantial cutbacks on agricultural users to restrictions on use of home sprinklers and car washing. The managed recession accounted for approximately 1 ft of lost water on the lake (with > 5 ft subsequently lost to evapotranspiration and water deliveries), so it is likely that these restrictions would have taken place regardless of whether or not the recession had been approved. However, it is unknown how the managed recession may have affected the initiation date or duration of these restrictions. Although normal to above-normal precipitation returned to South Florida in the fall of 2001, thereby abating the water shortage crisis, the restrictions during 2000–2001 resulted in economic hardships throughout the region. Not only were there water use restrictions in the South Florida region, but also economic impacts were felt by citrus, rice, and other agricultural industries, bait shop owners, hotel operators, fishing guides, trailer parks, and other segments of the economy integrally linked to public use of the lake resource. During the drought, a state of emergency was declared, allowing small-business owners to apply for low-interest loans. The main users of these loans were the commercial seine-fishing operators, who were not able to do any fishing when lake stage levels were low (SFWMD, *unpublished data*).

Figure X. Lake Okeechobee Managed Recessions Decision Tree

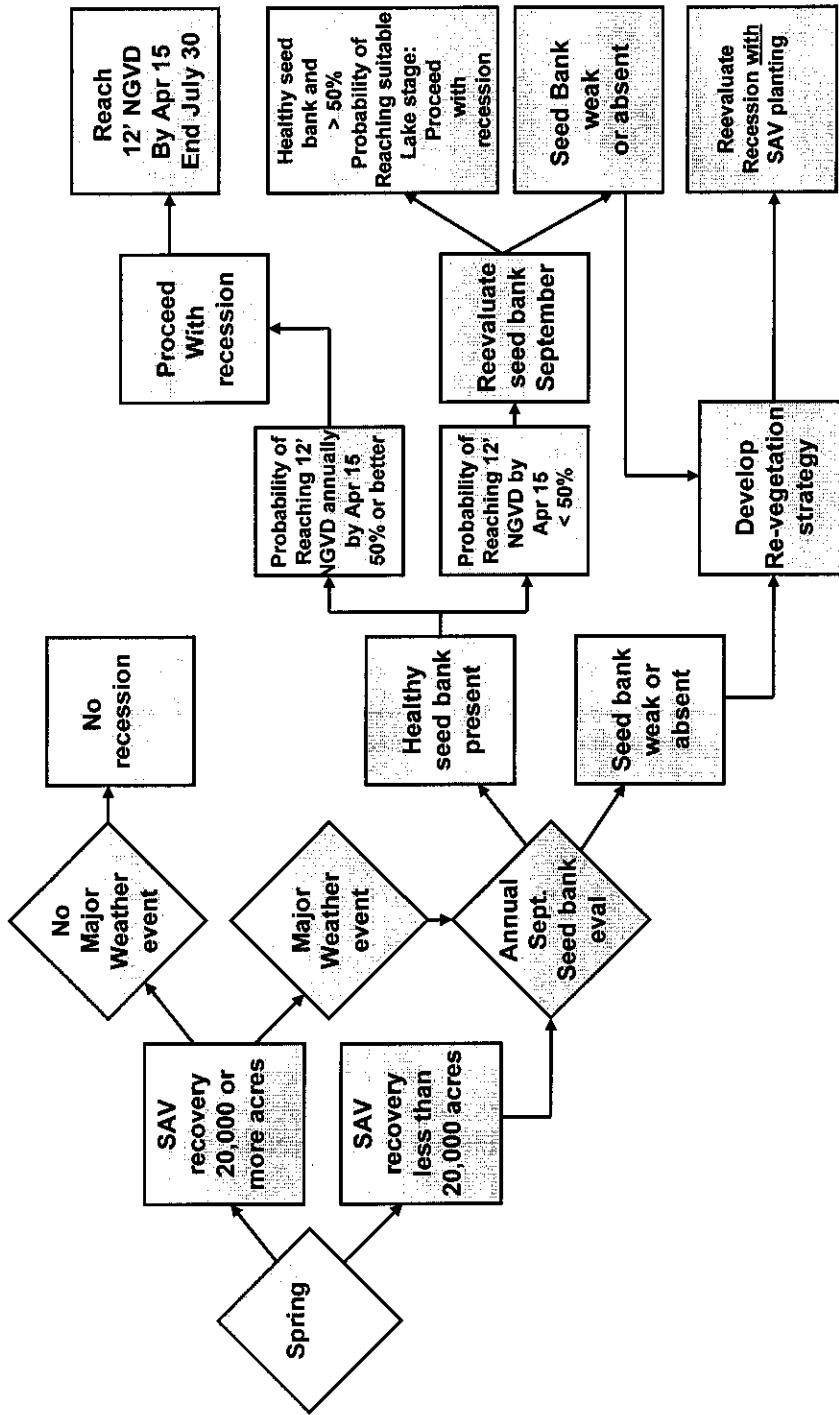
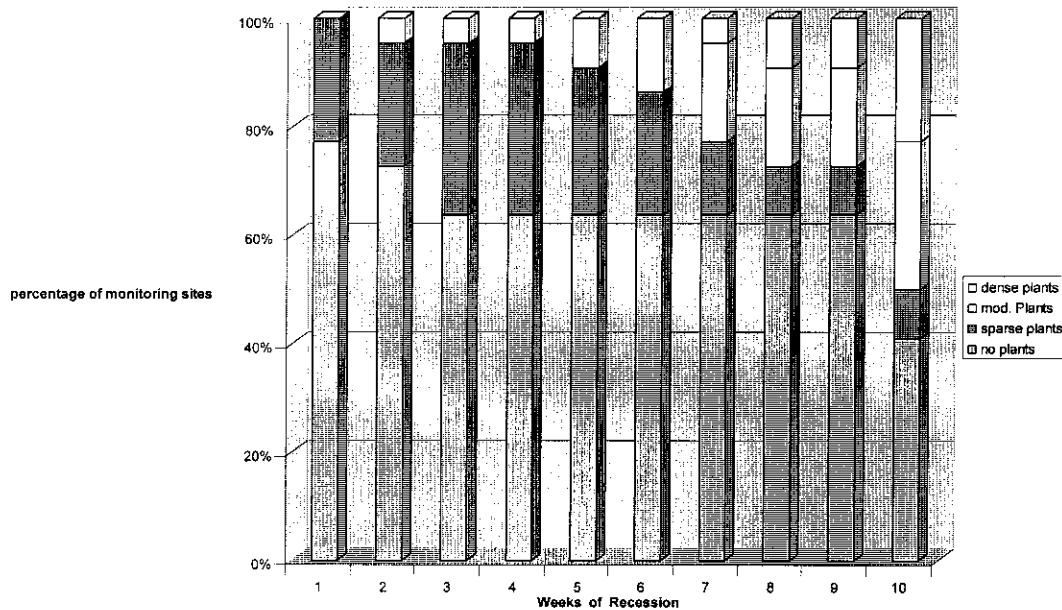


Figure X. Progression of Re-Growth of SAV Post- 2000 Recession



NATURAL RECESSION FREQUENCY

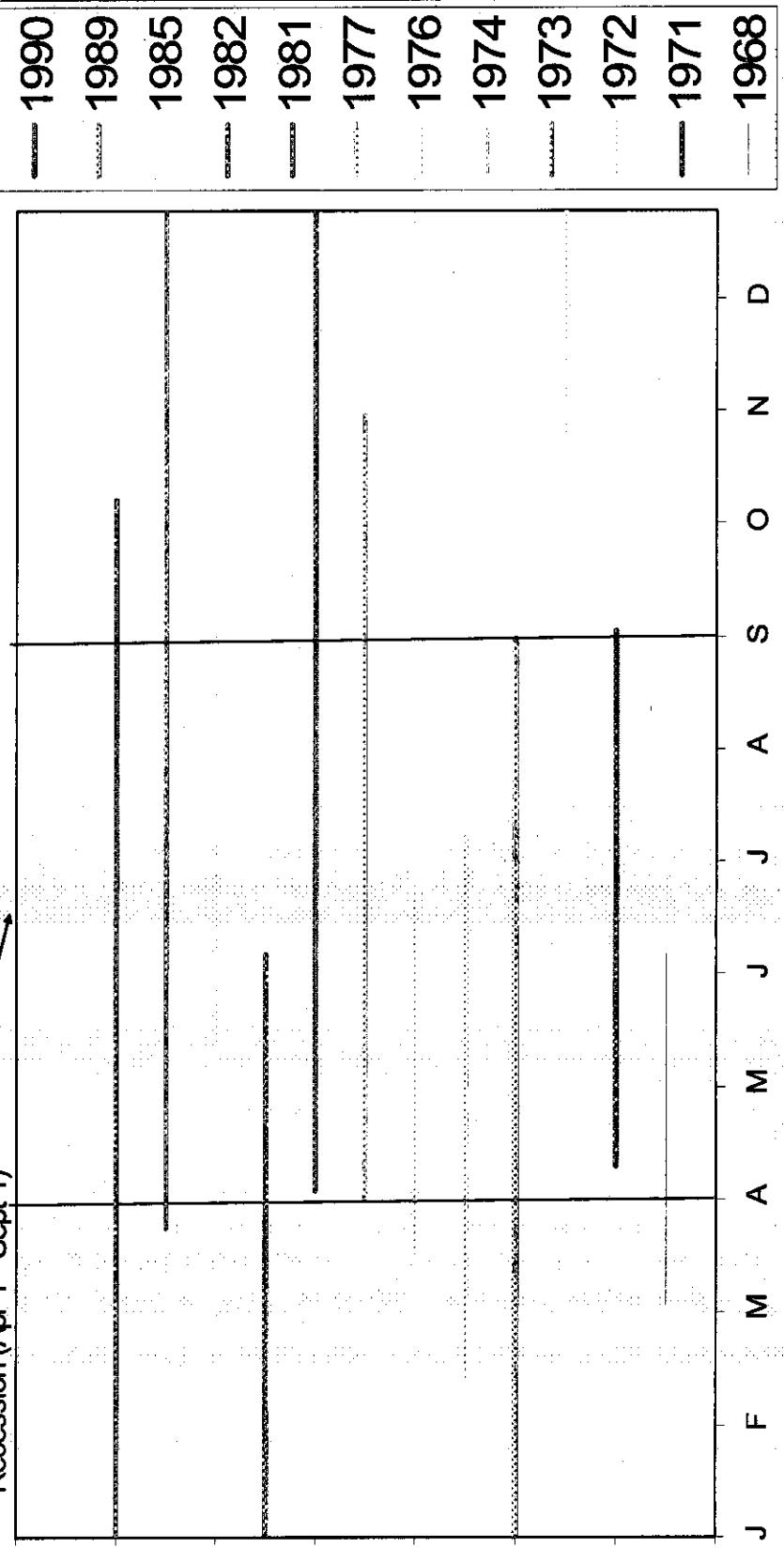
Bruce Shaffstein and Andy Rodusky
SFWMID

Premise and Goal

- Examine the frequency of natural recessions under the current operating schedule and under the TSP.
- Natural recessions considered capable of improving SAV in Lake Okeechobee defined as:
 - An elevation of <12.5' NGVD.
 - A duration of 12 weeks or more.
 - During the period April 1 to September 1.

07LORS (Base) \leq 12.5 ft

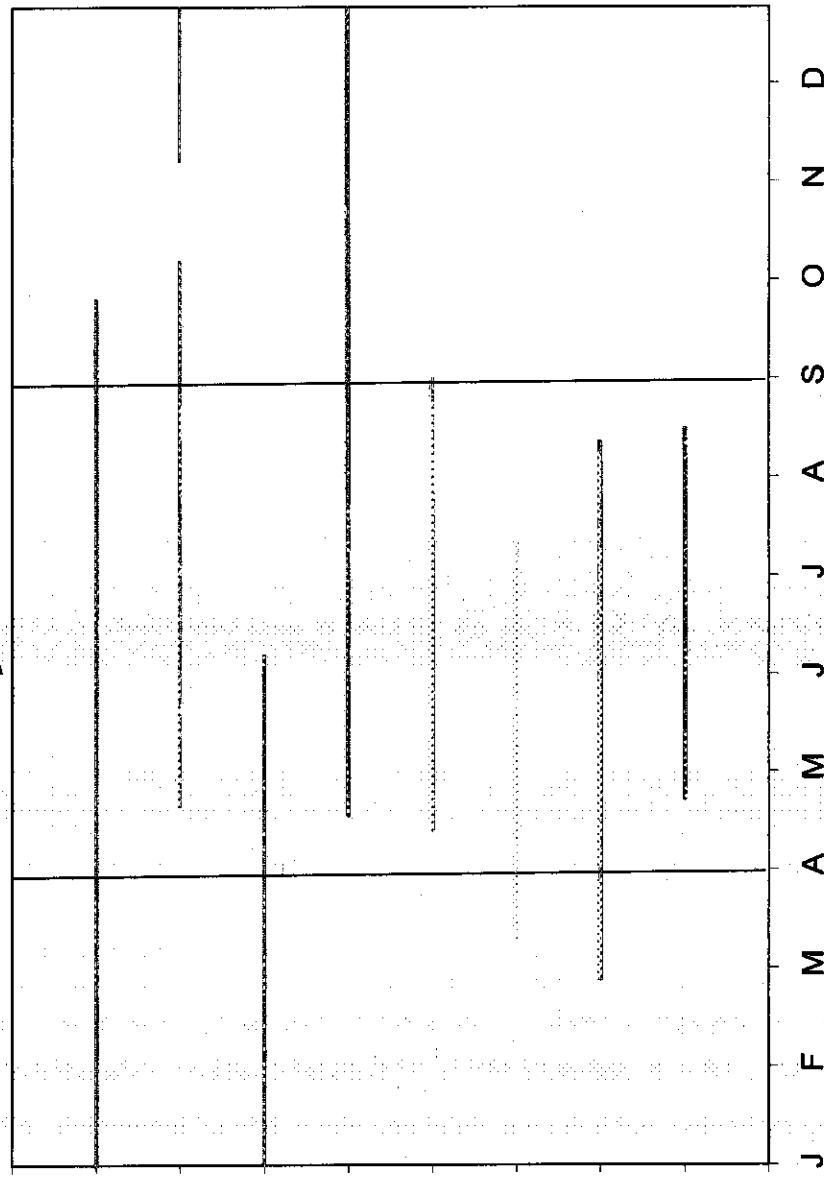
Opportunity Interval For A Successful
Recession (Apr 1 - Sept 1)

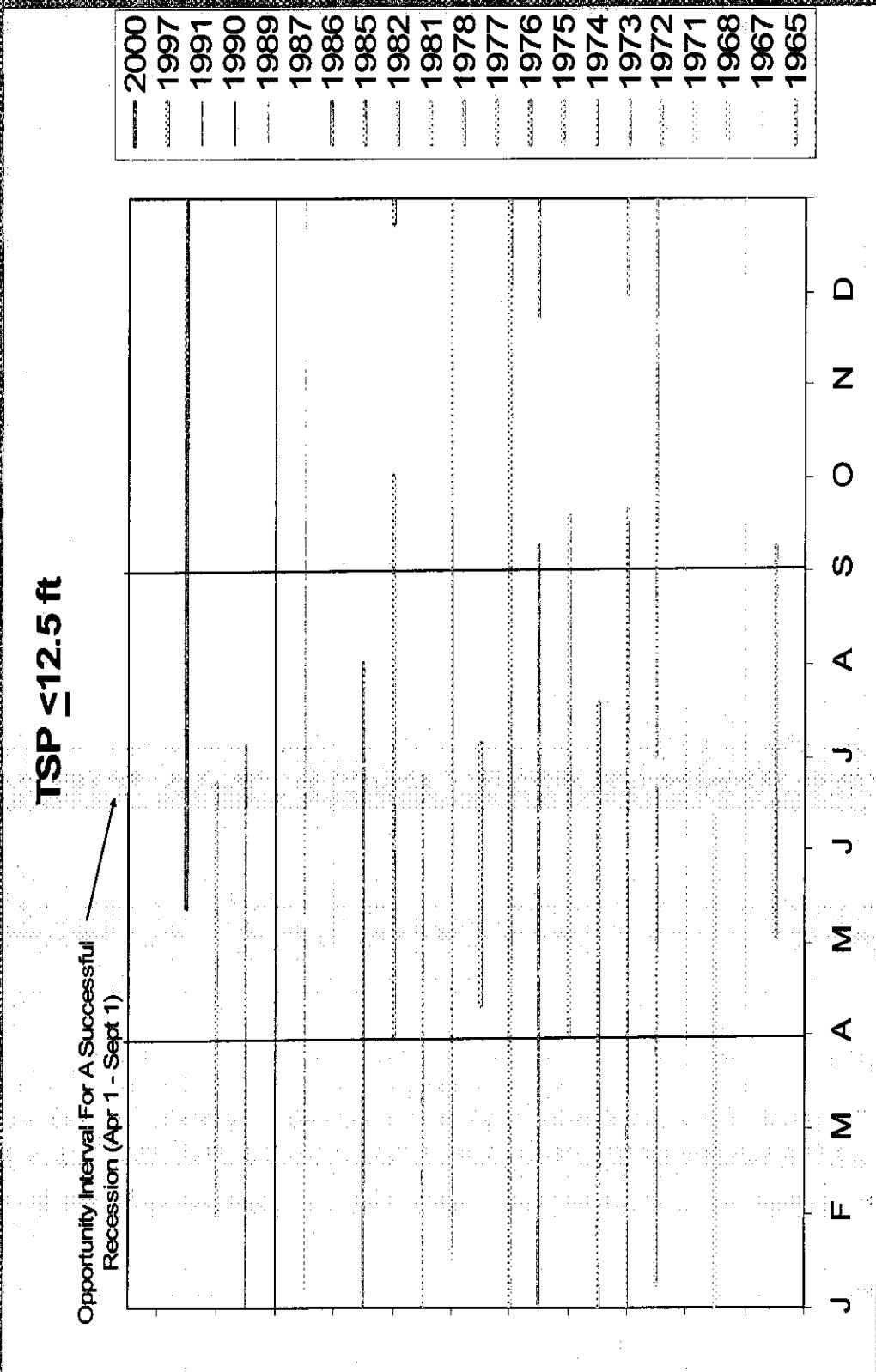


07LORS (Base) \leq 12 ft

Opportunity Interval For A Successful
Recession (Apr 1 - Sept 1)

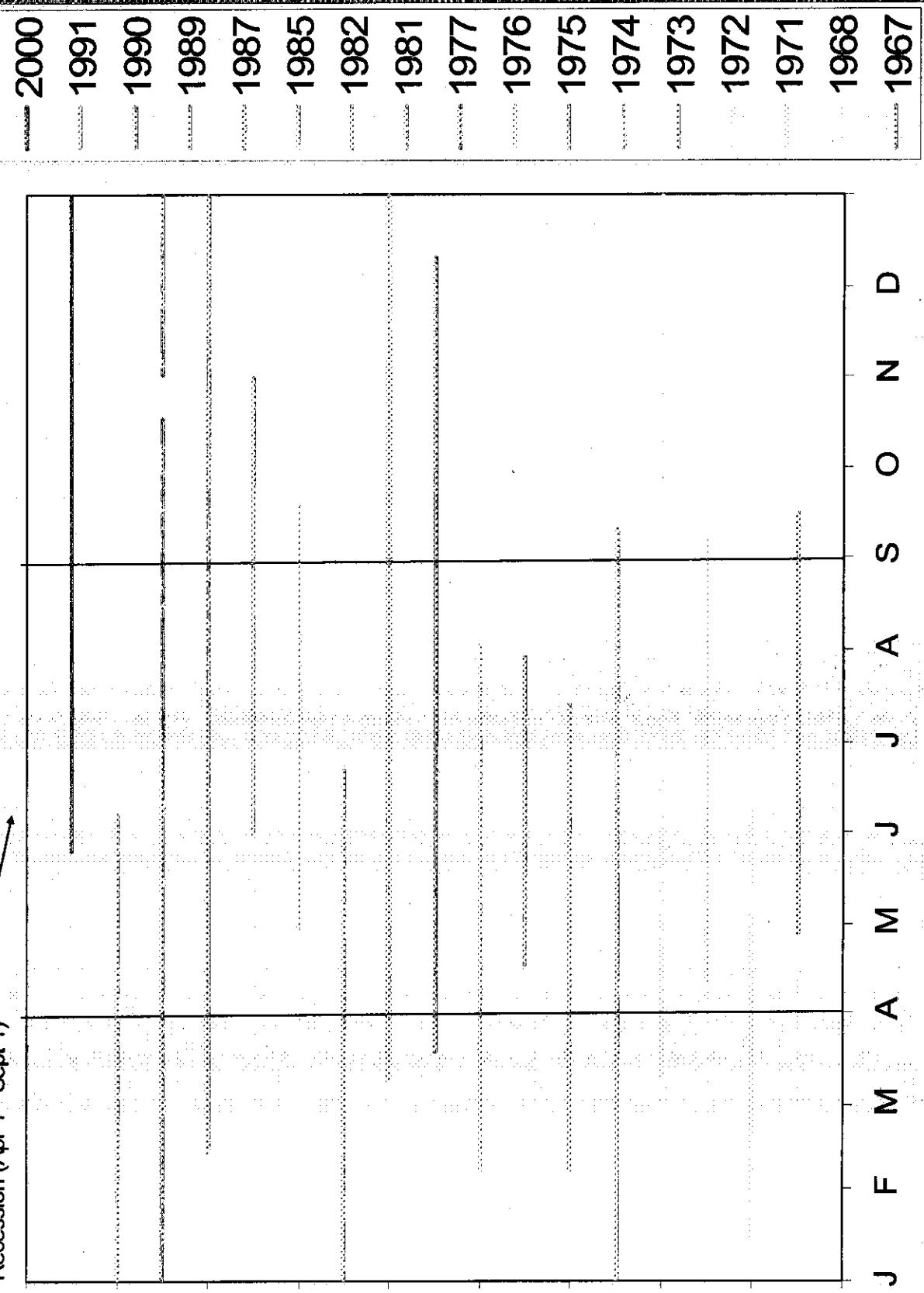
— 1990
— 1989
— 1982
— 1981
— 1977
— 1974
— 1973
— 1971





TSP \leq 12 ft

Opportunity Interval For A Successful
Recession (Apr 1 - Sept 1)



Summary Table

CONDITION	PROBABILITY OF A RECESSION BASED ON 36 yr por.
LORS $07 \leq 12.5'$	19%
LORS $07 < 12.0'$	19%
TSP $\leq 12.5'$	50%
TSP $< 12.0'$	36%

Conclusions

- TSP has a high probability of having natural recessions relative to the current schedule.
- Consequently, need to use managed recessions as a tool should be relatively infrequent.
- Nevertheless, ability to do managed recessions should remain an option to be used to promote recovery from catastrophic situations when absolutely necessary.

APPENDIX G

Evolution of Water Shortage Management Plan Assumptions

**South Florida Water Management District;
US Army Corps of Engineers, Jacksonville District**

November 2007

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INTRODUCTION

The SFWMD regulates Consumptive Use permits and administers Water Shortage allocations per SFWMD rules. In 2002, in response to lessons learned during the 2001 drought, the SFWMD began revising the Lake Okeechobee Surface Area (LOSA) water shortage rules. In 2005, the USACE (Corps) initiated a study to revise the existing Lake Okeechobee Regulation Schedule (WSE) with the goals of managing the lake at lower Lake elevations to reduce high discharges to the estuaries and improving the environmental impacts to the Lake from high Lake stages. During the plan formulation process, as additional information regarding the condition of the HHD became available, the purpose was refined to include increased emphasis on protection for public health and safety. The Corps (USACE) Lake Okeechobee Regulation Schedule Study (LORSS) evaluations included an assessment of water supply impacts along with other CERP RECOVER based performance measures. Inherent in the evaluation of water supply impacts is the need to simulate how the SFWMD allocates water during declared water shortages. This appendix chronicles the two agency's activities as they relate to the water supply capabilities of the Lake during extreme low conditions.

SFWMD LOSA WATER SHORTAGE RULE HISTORY

Pre 2002: Supply-side management

The Supply-Side Management Plan (Hall, 1991) – sometimes referred to as the SFWMD "Yellow Book" was SFWMD's method for distributing and conveying Lake Okeechobee water during the 1980-1981 1989-1990, and the 2000-2001 water shortages within the Lake Okeechobee Service Area (LOSA) and the Lower East Coast (LEC) Planning Area. The SSM plan was based on the physical constraint to making gravity based water supply deliveries from the Lake as the stage approaches 10 ft NGVD. The plan provided a method for calculating weekly allocations to LOSA users based on the storage capacity of the Lake leading up to a June 1st minimum lake target level of 11.0 feet using a mass balance approach that considered crop acreage, rainfall forecasts evapotranspiration, Lake stage/storage, and time of year. Under the plan, as the Lake stage approached the 11.0 ft. target elevation, the weekly allocations diminished to 40% on normal water demands. When it became apparent that the Lake could drop below 11 ft., the target elevation could be lowered making more water available for allocation under the drought albeit with excessive cutbacks. Ultimately, however, water deliveries to most of LOSA users would effectively cease when the Lake reached an elevation of 10.0 ft as the hydraulic gradients from the Lake were too low to cause water to flow from the Lake.

In the 2001 water shortage, temporary forward pumps were deployed on the Miami, Hillsborough/North New River, and Palm Beach canals which would allow for water supply deliveries to the EAA basins from the Lake at stage below 10 ft NGVD. The allocations for the water shortage were, once again based on the supply side management plan even though the pumps would make more water available from

the Lake. As a result, the weekly allocations were extremely restricted resulting extreme economic losses to the LOSA users. In administering the SSM plan during the 2000- 2001 drought, several shortcomings were realized including:

- ❖ Data used to calculate irrigation demands (rainfall, evapotranspiration [ET], water use acreage and crop type) were outdated and assumed normal rainfall and supplemental irrigation conditions, yet conditions during the drought were below normal resulting in allocations that were much lower than what was needed to sustain crops.
- ❖ Lake Okeechobee water budget did not consider tributary inflows thus understating the water available for allocation.
- ❖ Application of the method was complicated and not well understood by stakeholders and decision makers.
- ❖ Use of a reference stage was problematic in that it was constantly being changed rendering it cumbersome and controversial.

In response to these shortcomings, both the water user community and environmental advocates for the Lake wanted more certainty on how the water shortage allocations would be administered in the future. Coincident with the SFWMD's rulemaking efforts to establish minimum flow and levels for Lake Okeechobee in September of 2001, the SFWMD implemented changes to the water shortage rules governing allocations from Lake Okeechobee. Included in these rule changes was lowering of the SFWMD's water shortage rule's Zone A elevations by .5' in order to provide LOSA users with a 1 in 10 level of certainty (a SFWMD standard); the implementation of a phased cutback approach (replacing the target elevation concept); and linkage to minimum flow and level provisions. The phase 1 and phase 2 cutbacks (15 and 30%, respectively) would be implemented when the Lake was projected to remain above a June 1st Lake elevation of 10.5' NGVD. The relevance of this June 1st Lake elevation of 10.5' NGVD was tied to the Lake's MFL criteria. Phase 3 and 4 cutbacks (45 and 60%, respectively) were to be imposed when the Lake elevations dropped fell below 10.5' NGVD and the Lake's MFL criteria would be exceeded.

While the 2001 rulemaking revisions incorporated the phased cutback concept, several issues relating to the allocations and the distribution of those allocations remained unresolved. SFWMD staff met with stakeholders in an effort to resolve these concerns and in April, 2002 produced a draft, revised SSM Plan. While this revised plan was superior to the 1991 plan, it was still not satisfactory. The 2000 plan: continued to include a reference elevation concept (10.5' NGVD); included the concept of share accounts to distribute water between LOSA, the Seminole Tribe, and the Lower East Coast; and utilized drought forecast methodologies including long range rainfall forecasts and position analysis. Despite these changes, the public still found this process technically cumbersome and unpredictable. Ultimately,

this plan was rejected as a substitute for the 2001 water shortage rule. Efforts to improve the SFWMD's water shortage management program were not revived until the USACE initiated its LORSS in the fall of 2005.

LORSS WATER SUPPLY EVALUATION

The USACE began the LORSS in the summer of 2005. The objective of LORSS was, initially, to manage the lake at lower Lake elevations to reduce high discharges to the estuaries and improve the associated environmental impacts to the Lake from high Lake stages. During the plan formulation process, as additional information regarding the condition of the HHD became available, the purpose was refined to include increased emphasis on protection for public health and safety. The SFWMD participated on the LORSS Project Design Team and helped establish the performance measures to evaluate the alternatives and impacts of revised Lake regulation schedule alternatives. Included in these performance measures were measures for water supply performance.

Surrogate Water Supply Analysis: 2006 LORSS draft SEIS

The SFWMD recognized at the beginning of the study that in order to minimize potential impact to the water supply level of service within LOSA, it would require revisions to the existing water shortage management (SSM) rules and proposed that the USACE, in modeling the proposed alternatives, lower the SFWMD's existing water shortage trigger line by one foot. This proposed SSM trigger line change became known as the "surrogate" trigger line; the "surrogate" trigger line was recommended by the SFWMD technical team working on the parallel efforts to revise the SSM rules as representative of the anticipated water supply performance following the rule revisions. In July 2006, USACE released the original LORSS draft Supplemental Environmental Impact Statement (SEIS), which utilized the surrogate water shortage trigger line. The SFWMD attempted to parallel the USACE's process, but needed the LORSS TSP to complete its water shortage management plan analysis. Once the USACE published the original July 2006 draft SEIS, the SFWMD used the performance of this plan as a target for its water shortage plan rulemaking.

LOWSM Water Supply Analysis: 2007 LORSS draft SEIS

Using the water supply performance that resulted from the LORSS TSP (with the surrogate trigger line) as a goal, SFWMD staff set out to develop a phased water shortage schedule for incorporation into rule. The resulting water shortage proposal was referred to as the refined LOWSM (Lake Okeechobee Water Shortage Management) plan. The refined LOWSM plan successfully reproduced the performance that the TSP produced with the surrogate, imposing minimal water shortage cutbacks (15%) on allocations until the Lake stages dropped to very low levels (e.g. 9.0 feet on June 1st).

With the SFWMD's refined LOWSM plan being successful in reproducing the performance that the LORSS TSP produced with the surrogate, the SFWMD requested in its' official comment letter to the Corps for the original July 2006 draft SEIS, dated August 24, 2006, that the USACE replace the surrogate trigger line with the SFWMD's more refined LOWSM plan in the USACE's LORSS revised draft (June 2007) SEIS. The USACE accomplished this action; Appendix G of the LORSS revised draft (June 2007) SEIS (included as attachment 1 of this appendix) was prepared by the SFWMD to advise the USACE of the details and development history for the refined LOWSM plan. Attachment 1 (prepared by the SFWMD in February 2007) provides complete documentation of the development history behind the LOWSM trigger lines and operational rules that were assumed for the alternative evaluations provided within the LORSS revised draft (June 2007) SEIS, based on the SFWMD recommendations, and repeated within the LORSS Final SEIS.

The SFWMD's refined LOWSM plan was presented in a series of workshops in the fall of 2006 and spring of 2007, parallel with the USACE efforts to complete the LORSS revised draft (June 2007) SEIS. Concerns from environmental groups regarding this proposal and compatibility with the Lake's minimum flow and level rule criteria were identified. Specifically, it was noted that it was possible under the refined LOWSM plan that the Lake Okeechobee minimum flow and level rule (MFL) criteria would be exceeded without water restrictions being imposed. Such a situation was contrary to SFWMD rules and identified as unacceptable without additional efforts to review the Lake Okeechobee MFL criteria; the SFWMD suspended rule making on the refined LOWSM plan in May 2007 and informed the USACE that the SFWMD may not be able to revise the LOWSM trigger line below the current SSM trigger.

In May 2007, the USACE was preparing to release the LORSS revised draft (June 2007) SEIS for public review and comment. In response to the SFWMD's suspension of the LOWSM rule making process, the USACE conducted modeling analysis to quantify the potential effect on water supply performance if no change to the existing SSM trigger line was made. The range of potential water supply performance between the existing SSM trigger line and the SFWMD's refined LOWSM plan was bracketed and included in USACE water supply performance evaluation in the LORSS revised draft (June 2007) SEIS.

LOWSM EFFORTS CONCURRENT WITH THE LORSS FINAL SEIS PREPARATION

Coincident with the release of the LORSS revised draft (June 2007) SEIS, the LOSA was being subjected to water shortage restrictions as the stage of the Lake fell within the Zone A water shortage area as described in SFWMD Rule (40E-22, 40E-21 F.A.C.). Working with the Governing Board and stakeholders, the SFWMD imposed water shortage cutbacks consistent with the 2001 rule but based on crop demands as they occur during a 1 in 10 level drought (as opposed to average rainfall assumed conditions) and consistent with the SFWMD's MFL criteria. The

SFWMD held its last scheduled rule workshop in late summer, 2007. This workshop introduced a rule concept which reflected management of the Lake during the 2007 drought and was consistent with the 2001 version of the rule and the Lake's MFL criteria. The water shortage rule imposes more significant water restrictions earlier on through LOSA (compared to the existing water shortage management plan established in 2001). This proposal was supported by stakeholders and was presented to the SFWMD Governing Board for authority to publish the rule and adopt the rule, if no public hearing was requested. Because no hearing was requested by October 19, 2007 the "modified LOWSM" rule is expected to be effective November 15, 2007. SFWMD's Notice of Proposed Rule for Lake Okeechobee Water Shortage is provided as Attachment 2 of this appendix.

Though operational details for implementation have not been finalized by the SFWMD and provided to the USACE in time for publication in the LORS Final SEIS, the water shortage rule is expected to provide water supply performance within the bracketed range that was evaluated in the LORSS revised draft (June 2007) SEIS. Water supply performance is expected to fall closer to the evaluation provided for the existing water shortage rules than to the performance with the refined LOWSM. The Water Control Plan will be finalized with effects within the bracketed range for water supply performance documented in this SEIS. Changes to the Water Control Plan to reflect any modifications by the SFWMD to its water shortage management rules can be accommodated under this analysis so long as the SFWMD can demonstrate they do not result in impacts outside the bracketed performance range.



SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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October 4, 2006

Dennis R. Duke, P.E.
Chief, Restoration Program Division
U.S. Army Corps of Engineers
Jacksonville District
PO Box 4970
CESAJ-DR
Jacksonville, FL 32232-0019

Dear Mr. Duke,
Dennis

I understand from speaking with David Apple and Dan Crawford that U.S. Army Corps of Engineers (USACE) will be conducting sensitivity runs regarding the Tentatively Selected Plan (TSP) for the Lake Okeechobee Regulation Schedule Study (LORSS) in response – in part – to public comments received on the Supplemental Environmental Impact Statement (SEIS). I also understand there is some uncertainty on the part of USACE's management as to whether to include the latest version of South Florida Water Management District's (District) DRAFT Lake Okeechobee Water Shortage Management (LOWSM) Plan – formerly referred to as Supply-Side Management (SSM) – as part of the sensitivity run. I believe that the current version of the LOWSM plan should be included as part of the sensitivity runs based on the following:

- The one-foot lower SSM trigger line used in the TSP was a surrogate – provided at USACE's request in Feb. 2006 to meet the LORSS schedule for completion in Jan. 2007 – for the revised SSM plan now known as LOWSM. We believe the LOWSM assumptions now constitute the best available information and should be used in place of the one-foot surrogate.
- The LOWSM Plan – although not formally adopted by the SFWMD GB – was discussed at both the September WRAC and GB meetings with no objections noted.
- The LOWSM Plan was discussed at a meeting in late August of agricultural interests and no objections were noted.
- The LOWSM Plan improved water supply performance with no deleterious effects to other performance measures.
- Having raised concerns regarding this issue several times over the past few months, it was the District's understanding that USACE's strategy of modeling the TSP and a sensitivity run with the current trigger line – both included in the SEIS – provided two end members, and as long as LOWSM performance fell between these two end members, then the LOWSM Plan would be included without affecting the LORSS project schedule.

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Mr. Dennis Duke
October 4, 2006
Page 2

- To the extent that some of the TSP sensitivity run assumptions attempt to improve estuary performance measures – most likely at the expense of water supply performance – it would seem prudent to incorporate the LOWSM plan assumptions that might ameliorate these effects.
- It's my understanding that a conversation between you, Mr. Michael Collins, SFWMD Governing Board Member, and Scott Burns resulted in an understanding that the final TSP would include the LOWSM Plan.

For these reasons, I think it is prudent to incorporate LOWSM Plan assumptions into any TSP sensitivity runs to be conducted by USACE in the near future. Please advise if I can be of further assistance in resolving this matter.

Sincerely,



Chip Milam
Deputy Executive Director
Water Resources

cm/e

c: **Pete Kwiatkowski**
Pete Milam, USACE

ATTACHMENT 1

APPENDIX G

Lake Okeechobee Water Shortage Management Plan



**Prepared by the
South Florida Water Management
District**

February 2007

Lake Okeechobee Water Shortage Management Plan

Introduction

The South Florida Water Management District (SFWMD) has drafted a revised Lake Okeechobee Water Shortage Management (LOWSM) Plan – formerly referred to as the Supply-Side Management (SSM) Plan – to equitably distribute and convey water from Lake Okeechobee during dry periods. The LOWSM Plan was developed through regional modeling using the South Florida Water Management Model (SFWMM). Attachment A summarizes the principal hydrologic features and assumptions included in the SFWMM simulation. The version of the model used for the LOWSM simulations was derived from the one used by the U.S. Army Corps of Engineers (USACE) in their Lake Okeechobee Regulation Schedule Study (LORSS; USACE, July, 2006).

The LORSS version of the SFWMM is unique in that 1,400 cubic feet per second (cfs) of temporary forward pump capacity was assumed to be available to deliver water to the three major basins in the Everglades Agricultural Area (EAA), when Lake levels decline below an elevation of + 10.2 feet National Geodetic Vertical Datum (NGVD), where gravity flow normally ceases. USACE's Tentatively Selected Plan (TSP) – and for that matter all alternatives analyzed in the LORSS – assumed temporary forward pumps were available. In addition, to meet USACE's project schedule, a surrogate for a revised LOWSM Plan was included; that is, the currently adopted SSM trigger line was lowered one foot. In July 2006, USACE prepared a Supplemental Environmental Impact Statement (SEIS) based on the TSP, which – among other things – served as a starting point for development of a revised LOWSM Plan.

This document serves to advise USACE of the revised draft LOWSM Plan as part of SFWMD's official comments to the LORSS TSP. It is SFWMD's belief that the elements of the revised LOWSM Plan be incorporated into the final version of the LORS currently scheduled for adoption by USACE in January 2007.

Background

The Supply-Side Management Plan (Hall, 1991) – sometimes referred to as the "Yellow Book" was SFWMD's method for distributing and conveying Lake Okeechobee water during the 1981-1982 and 1990-1991 dry periods to the Lake Okeechobee Service Area (LOSA) and the Lower East Coast (LEC) Planning Area. Figure 1 is a location map showing Lake Okeechobee, the LOSA and LEC areas, and other areas of interest including the St. Lucie and Caloosahatchee estuaries. Figure 2 shows the various sub-basins of LOSA.

Several shortcomings of the original SSM Plan were realized during its application to the 2000-2001 drought including:

- Data (rainfall, evapotranspiration [ET], and water use) used are outdated and assume normal conditions, yet clearly conditions are not normal during a drought
- Lake Okeechobee water budget did not consider tributary inflows
- Application of the method was complicated
- Use of a reference stage

In response to these shortcomings, a revised SSM Plan (SFWMD, April 2002) was developed that assumed the use of the "reference elevation" and "user account" concepts. While this revised plan was superior to the 1991 plan, stakeholders expressed concern that the revised plan was cumbersome and did not assume the use of temporary forward pumps (1,400 cfs) that were available in the 2000/2001 drought. Stakeholders proposed a phased cutback approach – similar to how urban users are treated during droughts depending on the drought's severity.

In response to stakeholder input, a revised (hybrid) SSM methodology was presented and received concurrence from the SFWMD's Water Resources Advisory Commission (WRAC) at their March 2005 meeting (Attachment B). The hybrid plan incorporated both the phased-cutback approach and assumed existence of the temporary forward pumps. In addition, the phased cutbacks would be incorporated via a calendar-based approach related to Lake levels, focusing not simply on demands but on the resource itself.

The hybrid plan recognized the need to better estimate in real time supplemental irrigation demands (i.e., demands not met by local rainfall or storage) from LOSA on the Lake. The timeframe to conduct research on these supplemental demands and equate them to actual crop-specific water usage within LOSA did not match the need to have a revised plan within the timeframe of the revised LORSS (January 2007). Accordingly, the revised LOWSM Plan used a simplified approach as described below.

Lake Okeechobee Water Shortage Management (LOWSM) Plan

Goals

The Goals for the LOWSM Plan were to:

- Develop a revised LOWSM Plan that:
 - is simpler to understand
 - is easier to implement
 - includes a phased-cutback approach similar to that used for utilities during declared water shortages and
 - incorporates temporary forward pumps

as outlined in the Hybrid SSM Plan presented to the WRAC in March 2005

- Use updated data that is more realistic for drought conditions
- Develop a methodology that is adaptive to changing drought conditions
- Better meet water supply demands while not lowering lake levels below

Methodology

The primary elements of the revised LOWSM Plan include

- Calendar-based water shortage trigger line
- Calendar-based lines for phased cutbacks
- Expected weekly LOSA supplemental demands to be experienced under drought conditions

Calendar-based Water Shortage Trigger Line

A calendar-based water shortage trigger line was developed to ensure that the resource (i.e., Lake Okeechobee) is protected by taking into consideration periods of high and low Lake levels. This consideration is appropriate given the distinct wet- (June through October) and dry-season (November through June) periods experienced in South Florida.

Calendar-based Lines for Phased Cutbacks

For the same reason that calendar-based lines are appropriate to trigger a water shortage, they are also appropriate to implement phased cutbacks to water deliveries during droughts. Depending on the time of year and the severity of the drought, calendar-based cutbacks can be conducted, balancing water demands and protection of the resource.

Developing Weekly LOSA Demands

Developing weekly water supply demands for LOSA is a critical component of the water shortage strategy for the Lake. They are an essential input to the model upon which cutbacks would be conducted depending on the severity of the drought. These weekly demands were obtained by:

1. aggregating daily simulated LOSA supplemental demands from the SFWM
2. performing frequency analysis of these demands
3. selecting the appropriate demand curve

4. calculating daily demand based on the selected hydrologic condition (in this case, 1-in-10 condition) weekly demand, and dividing the weekly demand by the number of days with deliveries within the week

Figure 3 presents a graph of weekly demands (in acre feet [ac-ft]) vs. time for LOSA under different drought conditions. SFWMD Water Use rules typically allocate water to ensure that the level of service is maintained and no harm is done to the resource under a 1-in-10-year drought scenario. Accordingly, the 1-in-10-year curve was selected as the basis for this analysis. For example, the 1-in-10-year demand curve on Figure 3 indicates that the daily demand on January 1 is 21,000 ac-ft divided by 7, or 3,000 ac-ft.

Figure 4 presents the phased-cutback methodology proposed for the LOWSM. As an example, Figure 4 shows a hypothetical Lake stage of 9.3 feet on January 1, corresponding to a Phase 3 water restriction. As shown on the small table on Figure 4, a Phase 3 restriction correlates to a 45 percent reduction in water deliveries. In this example, the maximum delivery will be 3,000 ac-ft multiplied by 1 minus 0.45 (0.55) or 1,650 ac-ft.

The actual water delivery from the model is the minimum of the maximum delivery and the daily simulated demand. For example, if the model simulated demand is 1,400 ac-ft, the minimum of the daily model simulated demand (1,400 ac-ft) and the maximum model delivery (1,650 ac-ft) is 1,400 ac-ft. Conversely, if the daily demand is 1,800 ac-ft, the minimum of the daily model simulated demand (1,800 ac-ft) and the maximum model delivery (1,650 ac-ft) is 1,650 ac-ft.

Development of Phased Trigger Line and Cutbacks

The trigger line and phased-cutback lines were developed based on several model iterations designed to meet demands while protecting the resource (i.e., not allowing Lake stage to go too low). In each case, the previous SSM methodology used in the TSP was removed and replaced with a revised methodology. In all cases, the limiting criteria to establish the new LOWSM Plan was to equal or improve the performance of USACE's TSP, including not lowering the Lake beyond the minimum elevation of the TSP simulation (in this case, +8.8 ft NGVD). Evaluation of demands not met included the percentage of demands not met and cutback volumes. Sensitivity analysis was conducted by changing the height and inflection points of the trigger and phased-cutback lines to optimize performance (i.e., minimize cutback volumes without negatively affecting the low Lake elevation of +8.8 ft NGVD).

Results

The results of the analysis are presented and summarized in Figures 5 through 16, comparing and contrasting the TSP and the TSP coupled with the new version of the LOWSM Plan. Figure 5 presents stage-duration curves for Lake Okeechobee corresponding to USACE's TSP and TSP-LOWSM. The curves are

virtually identical, confirming that the LOWSM Plan either equals or exceeds performance of the TSP.

Figure 6 summarizes the mean annual flood control releases from Lake Okeechobee for both the TSP and TSP-LOWSM. The graphs indicate virtually identical performance.

Figure 7 displays the start and end dates, durations, and days since previous event for Lake Okeechobee stage excursions below elevation 11.0 ft NGVD in the period of record. Highlighted entries represent events lasting 80 days or longer, separated from previous events by more than 80 days. Again, the occurrences and durations of the events are similar for the TSP and TSP-LOWSM.

Figure 8 is a frequency analysis of the duration of Lake Okeechobee excursions below +11 ft-NGVD. This corresponds to the current elevation for the State-adopted minimum flow and level (MFL) for the Lake. The similarity of the return frequency curves shows a slightly improved performance of TSP-LOWSM vs. the TSP.

Figure 9 displays the LOSA demand cutback volumes for the seven years in the 36-year simulation with the greatest cutbacks. For all but 1982, the cutback volumes were reduced in these drought years, and in 1982 the cutbacks were increased only slightly.

Figures 10 and 11 are graphic displays of the frequency of water restrictions for LOSA for given water years and for given months of the year. Comparison of Figures 10 and 11 indicates a reduction in the number of months that water restrictions are imposed, as represented by the reduced number of "C"s displayed.

Figure 12 presents a graph of monthly cutback volumes vs. time over the simulation period. From this graph, it is clear that the cutback volumes are reduced from the TSP to TSP-LOWSM for many of the drought years.

Figure 13 summarizes the number of months of simulated water supply cutbacks for the various urban service areas of the Lower East Coast (Figure 1). Figure 14 presents the regional water deliveries for the same areas. Similar performance is observed for the TSP and TSP-LOWSM scenarios.

Figure 15 summarizes the number of times the salinity envelope is not met for the Caloosahatchee estuary (Figure 1), indicating the target, the TSP, and TSP-LOWSM scenarios. The salinity envelope is the preferred range of salinity values deemed to be "healthy" for the particular estuary based in part on its size, location, and historical flow regime. Figure 15 indicates TSP-LOWSM has

slightly better performance than the TSP, but below the target number of occurrences for high, potentially damaging flows above 2,800 cfs.

Figure 16 summarizes the number of times the salinity envelope is not met – this time for the St. Lucie estuary (Figure 1). Figure 16 indicates similar and slightly better performance for TSP-LOWSM vs. the TSP, but both below the target number of high flows greater than 2,000 cfs.

Summary and Conclusions

The South Florida Water Management Model (SFWMM) model was used to develop a revised Lake Okeechobee Water Shortage Management (LOWSM) Plan that resembles the water supply performance of USACE's Tentatively Selected Plan (TSP) for the Lake Okeechobee Regulation Schedule Study (LORSS). The LOWSM Plan incorporates the use of temporary forward pumps (1,400 cfs capacity), designed to make water deliveries southward at Lake elevations below +10.2 ft-NGVD that are normally not possible under gravity flow conditions. The LOWSM Plan incorporates a phased-cutback approach to water deliveries during droughts, similar to the water-shortage approach used in urban areas. Key conclusions are:

- The low lake level (+8.8 ft-NGVD) is the same for both the TSP and the TSP combined with the revised LOWSM
- The TSP keeps water users whole but with increased risks associated with increased frequency and duration of extreme low lake levels
- Increased risk of low lake events is moderated by the revised LOWSM and operation of temporary forward pumps

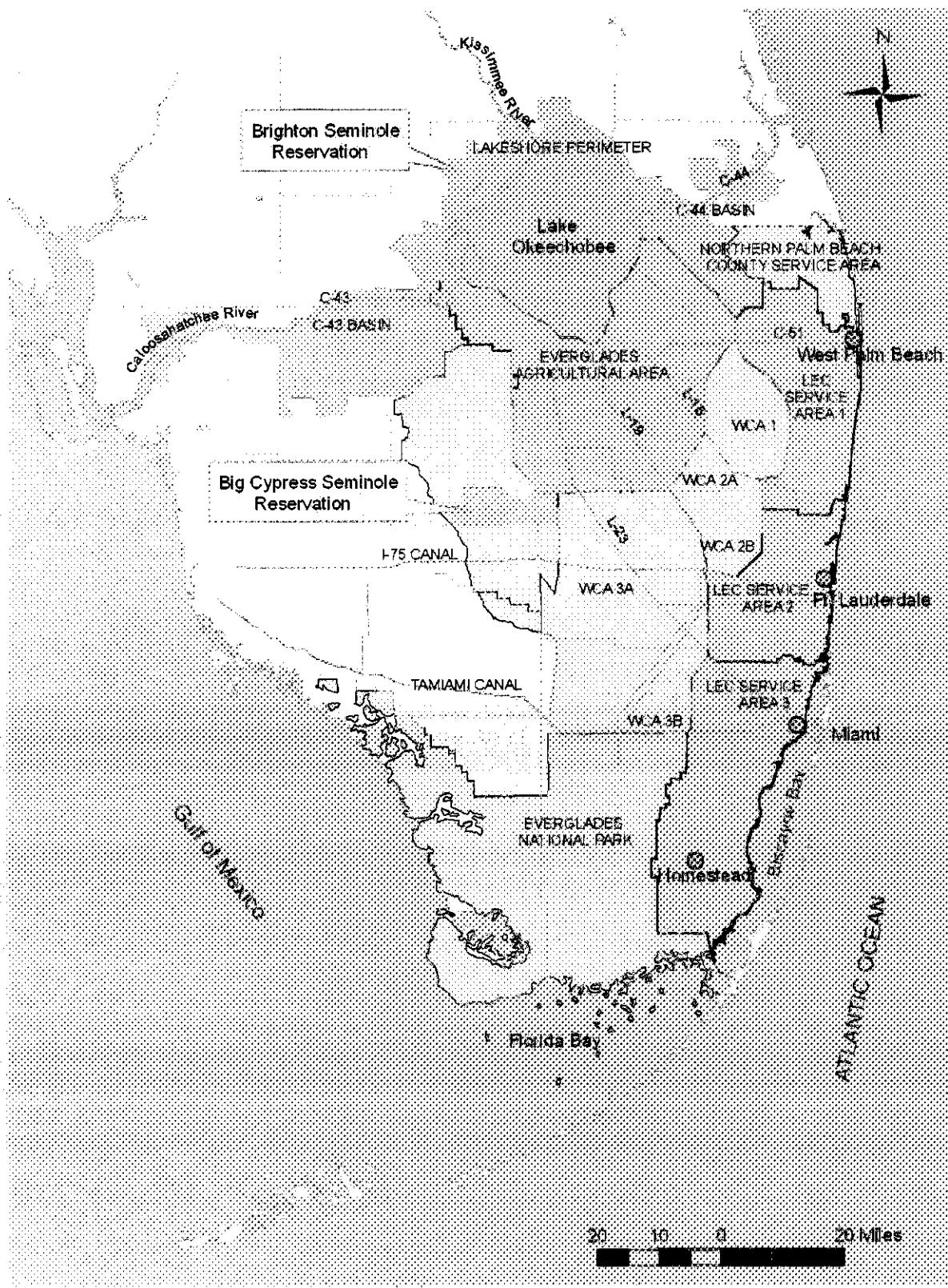


Figure 1.

Lake Okeechobee Service Area (LOSA)

Subdivision Boundaries

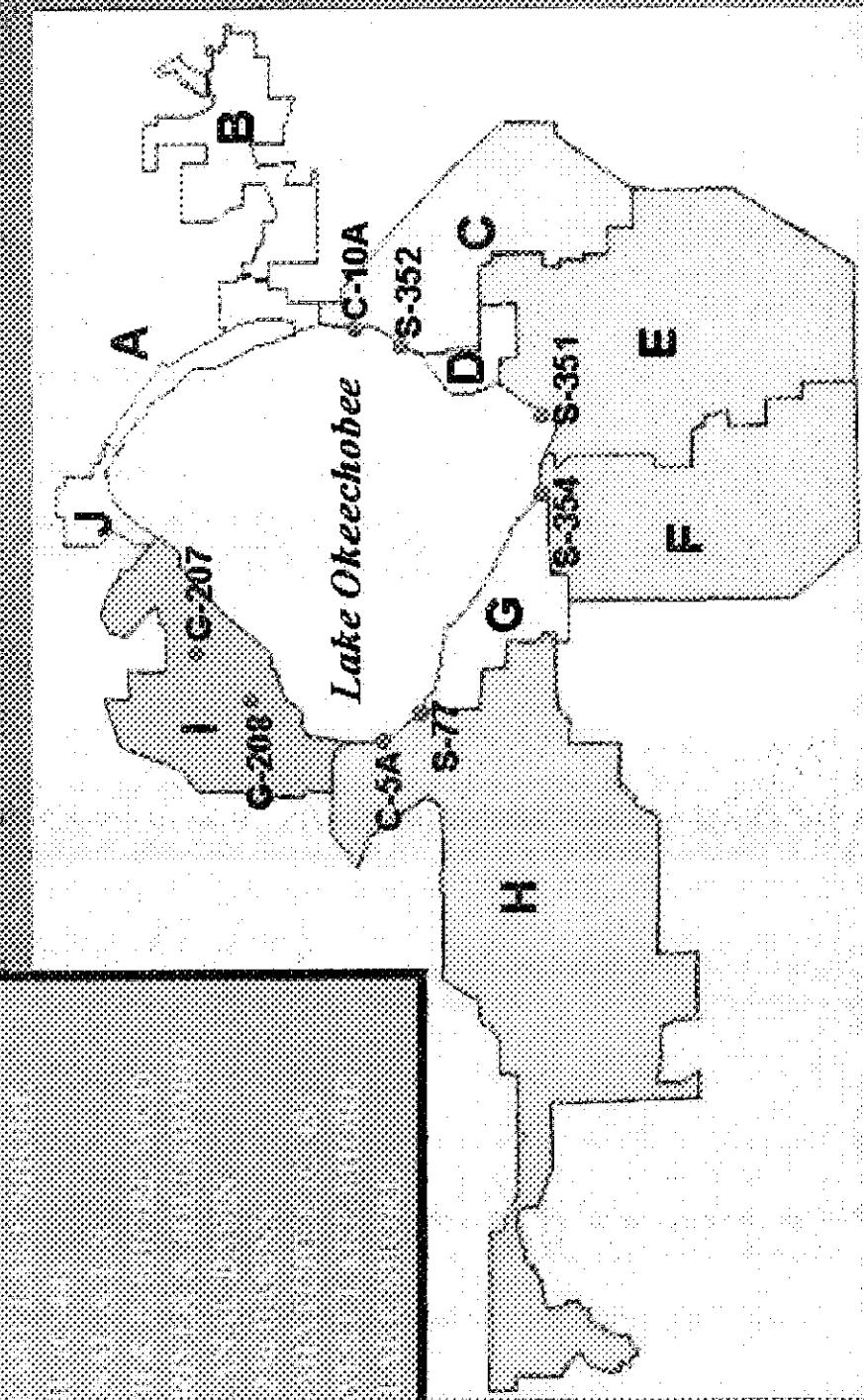


Figure 2.

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LOSA Weekly Demands for Different Drought Conditions

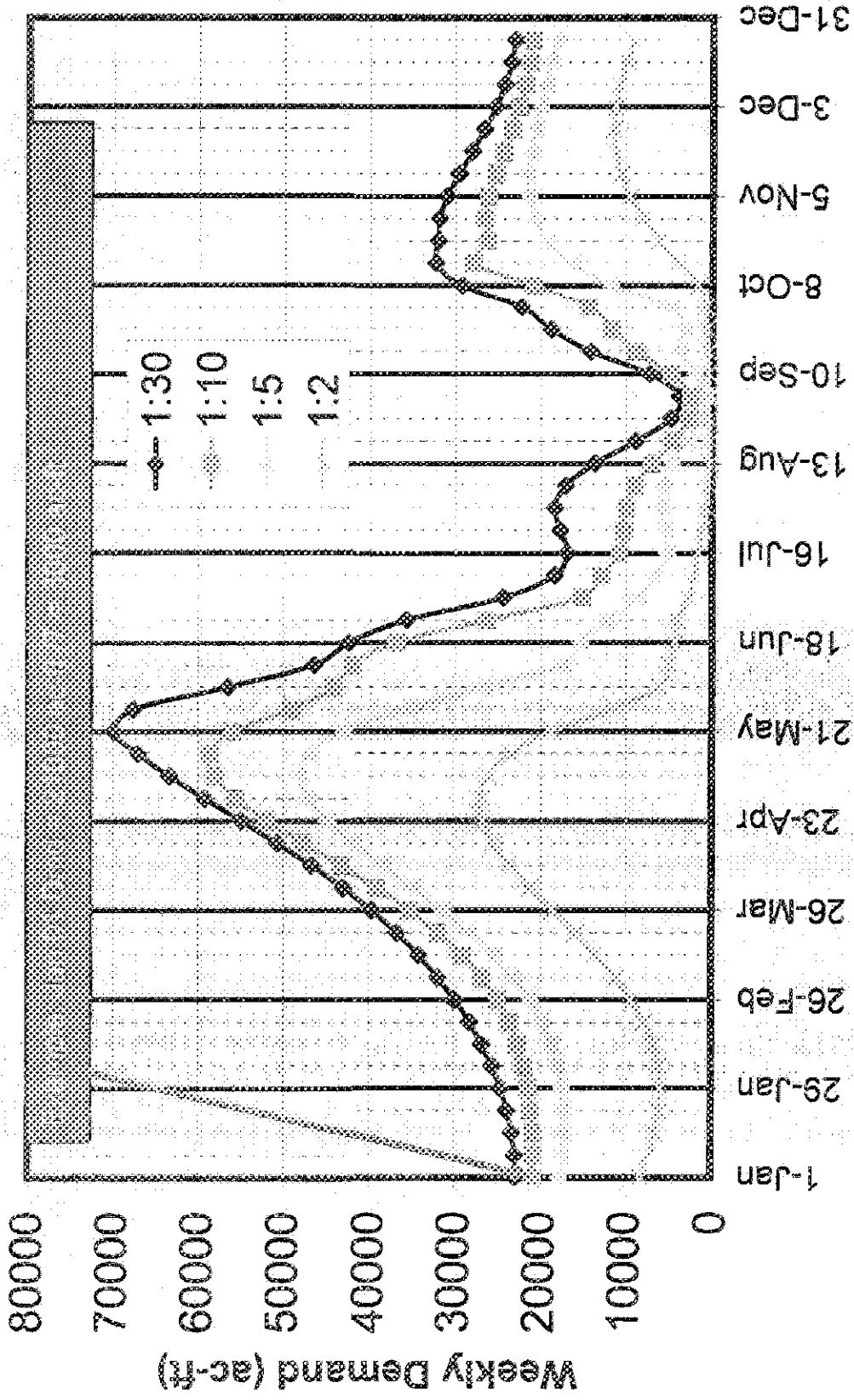


Figure 3.

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Trigger and Phase Lines used in LOWISM

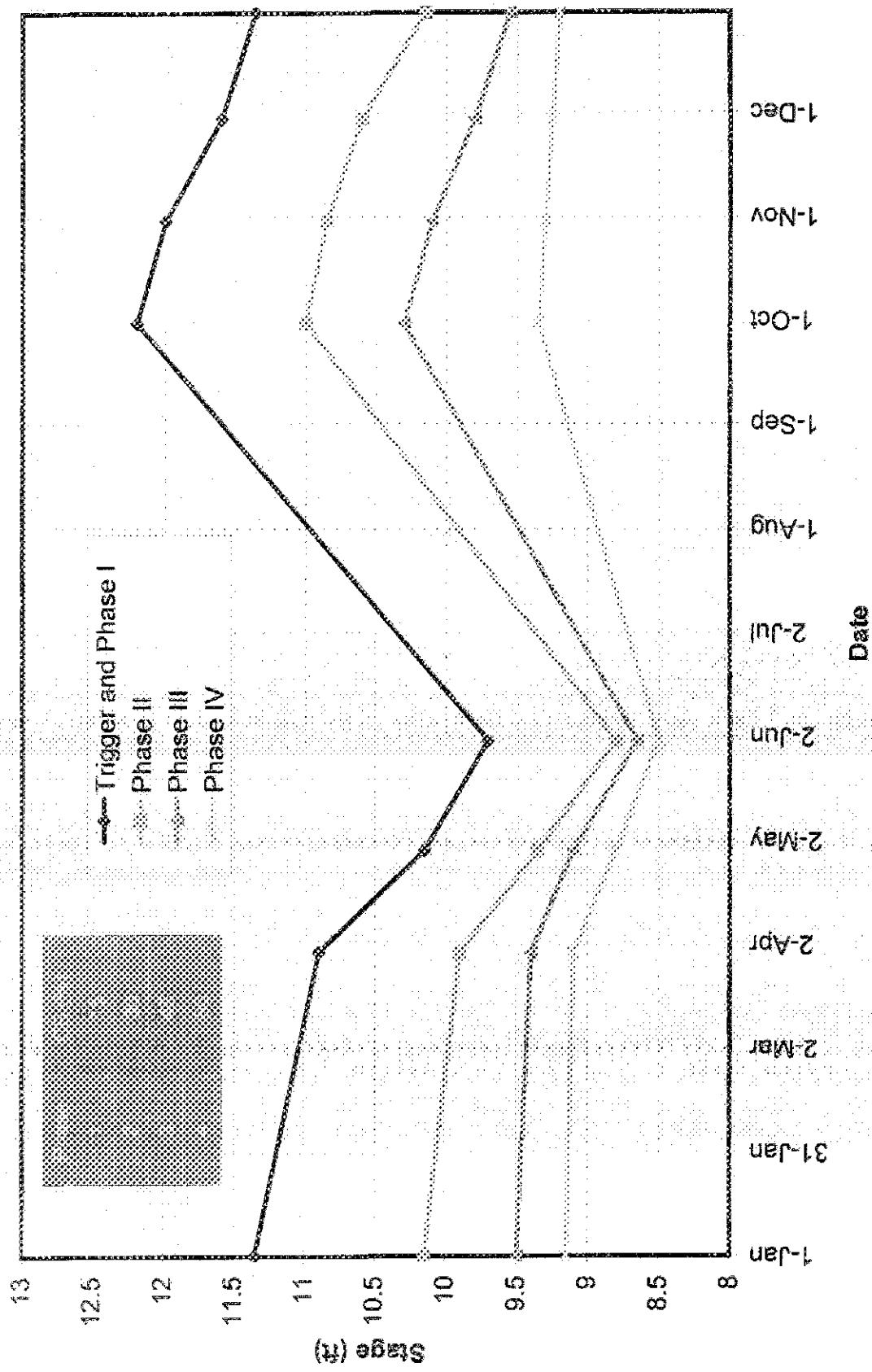


Figure 4.

Stage Duration Curves for Lake Okeechobee

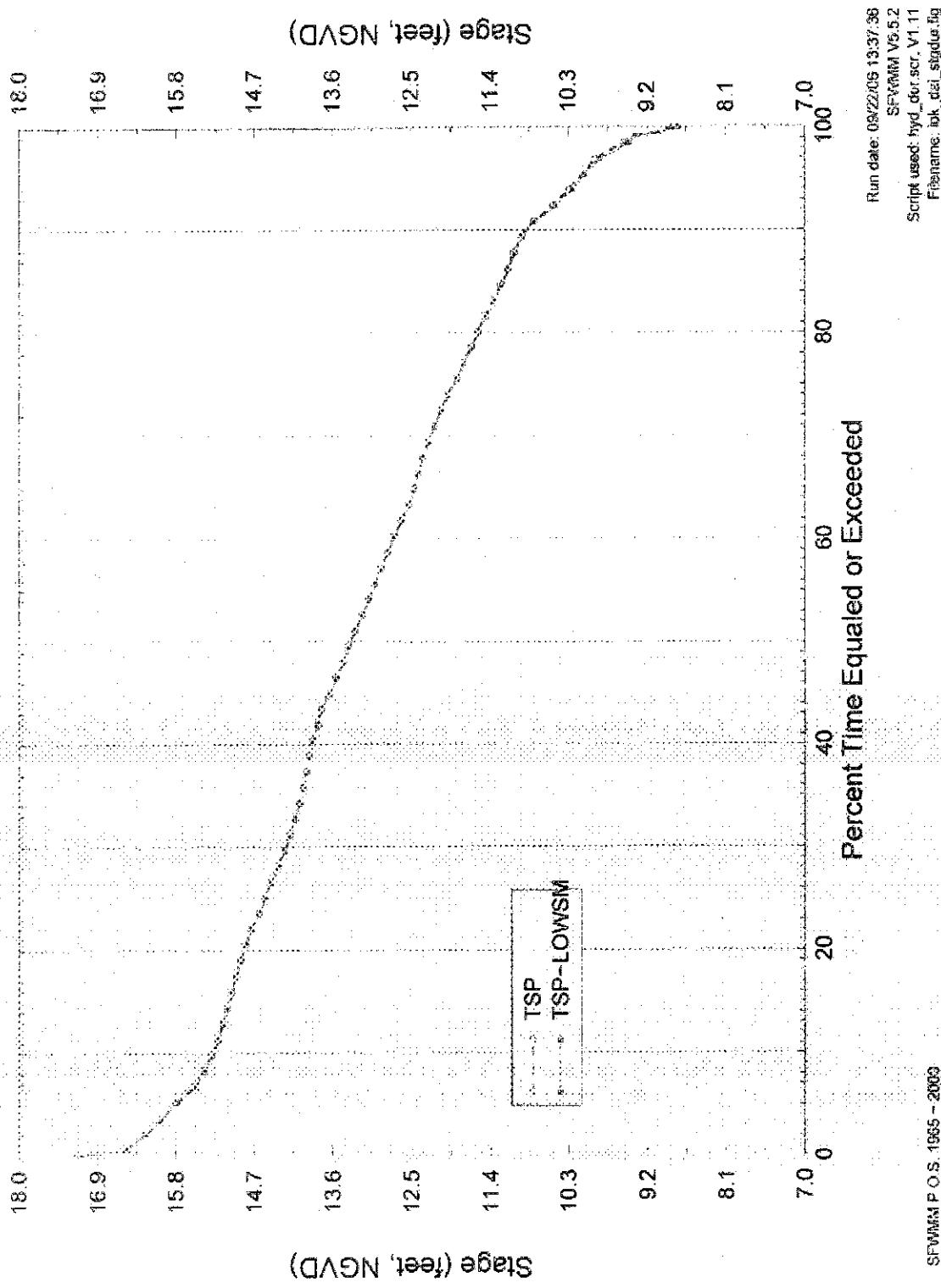
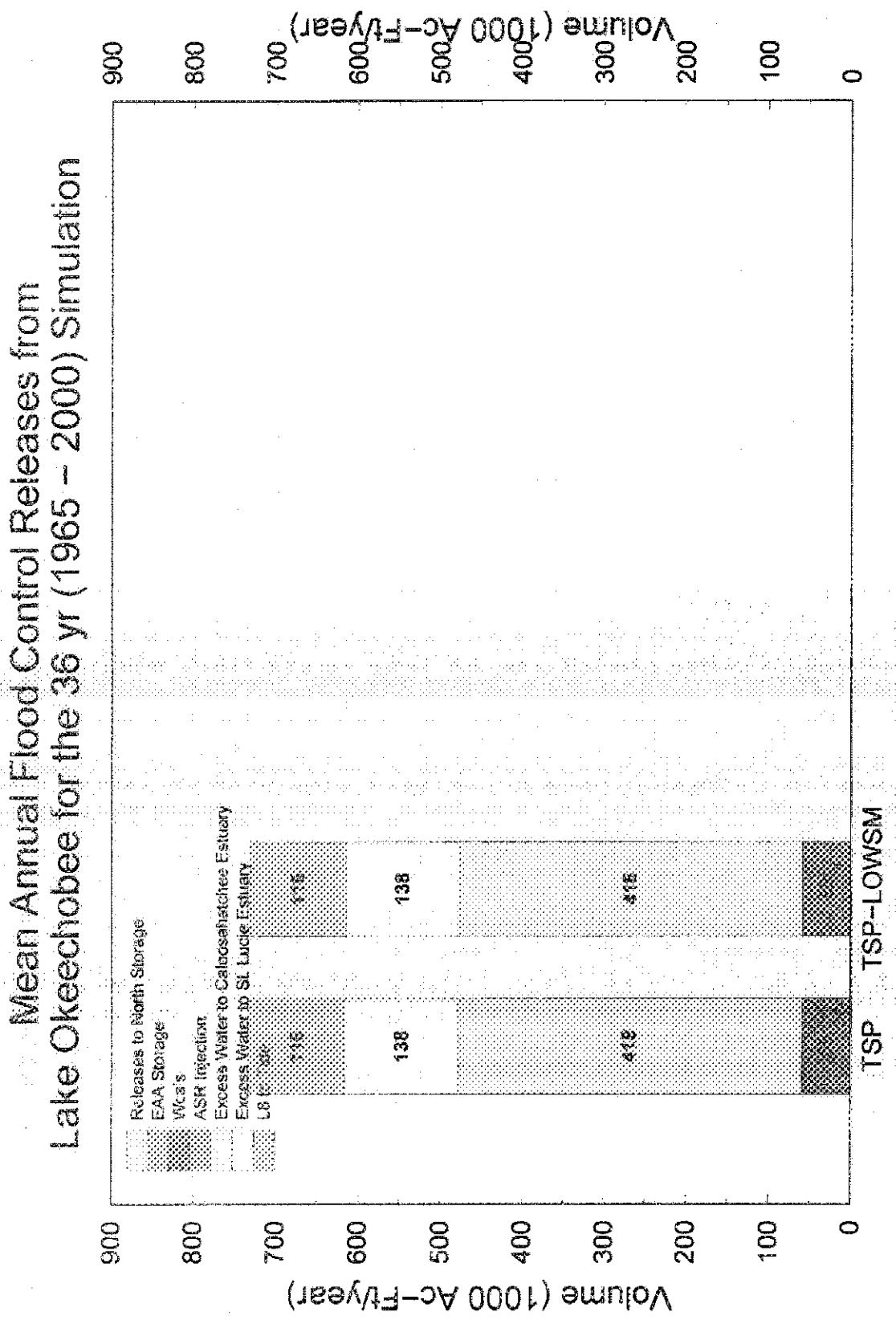


Figure 5.

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Note: Although regulatory (load control) discharges are summarized here in mean annual values, they do not occur every year. Typically they occur in 2-4 consecutive years and may not occur for up to 7 consecutive years.

Figure 6.

TSP	Start Date	End Date	Duration	Event	Days since Prior
	6/1/1967	6/18/1967	18	0	
	4/7/1968	6/3/1968	58	293	4/6/1968
	5/4/1971	7/23/1971	81	483	5/3/1971
	12/16/1972	12/22/1972	7	511	12/12/1972
	12/26/1972	1/22/1973	28	3	3/8/1973
	3/18/1973	3/26/1973	9	54	3/17/1973
	4/6/1973	7/31/1973	117	10	4/6/1973
	3/24/1974	7/3/1974	102	235	3/24/1974
	4/3/1976	4/6/1976	4	639	4/3/1976
	4/10/1976	6/4/1976	56	3	4/9/1976
	4/11/1977	9/5/1977	143	310	4/11/1977
	4/11/1981	6/2/1982	418	1313	4/11/1981
	6/6/1985	7/25/1985	50	1099	6/7/1985
	8/1/1985	8/6/1985	6	6	7/15/1985
	5/17/1986	5/21/1986	5	283	8/2/1985
	5/24/1986	6/16/1986	24	2	5/17/1986
	5/10/1989	10/5/1989	143	1656	5/24/1986
	2/9/1990	8/15/1990	188	126	5/9/1989
	12/19/2000	12/31/2000	13	3778	2/3/1990
					2/4/1990
					2/1990
					8/16/1990
					10/6/1990
					1/1991
					10/57
					119
					3
					4
					3777

TSP-LOWSM

					Days since Prior
					Event
					0
					293
					1063
					507
					39
					8
					10
					10
					235
					639
					5
					5
					57
					1
					310
					1313
					1098
					8
					283
					4
					24
					3
					4
					3777

7/20/1981 8.843

7/24/1981 8.746

Figure 7.

Frequency Analysis - LOK Excursions Below 11.0 ft

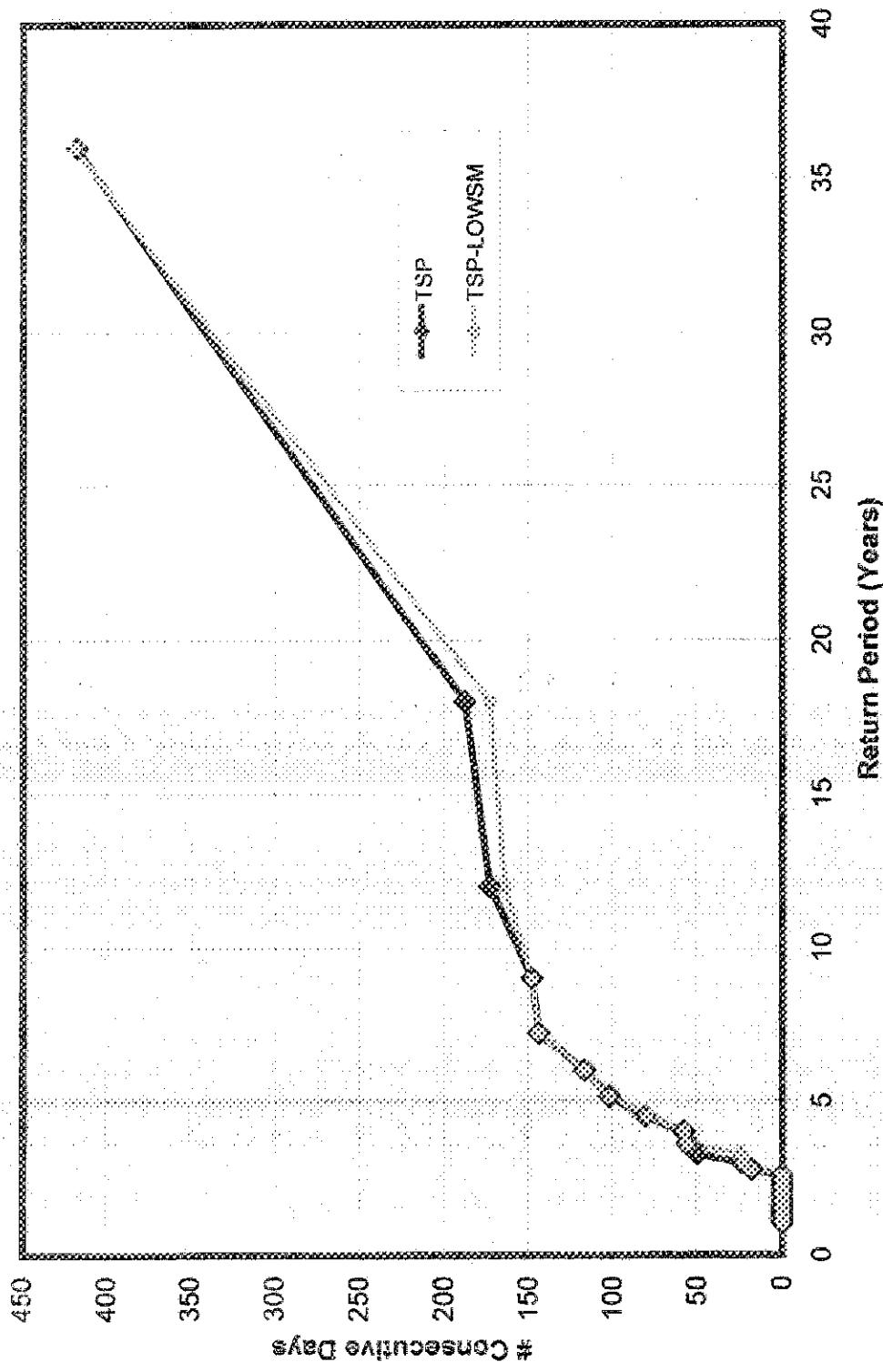


Figure 8.

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Water Year (Oct-Sep) LOSA Demand Cutback Volumes for the 7 Years in Simulation Period with Largest Cutbacks

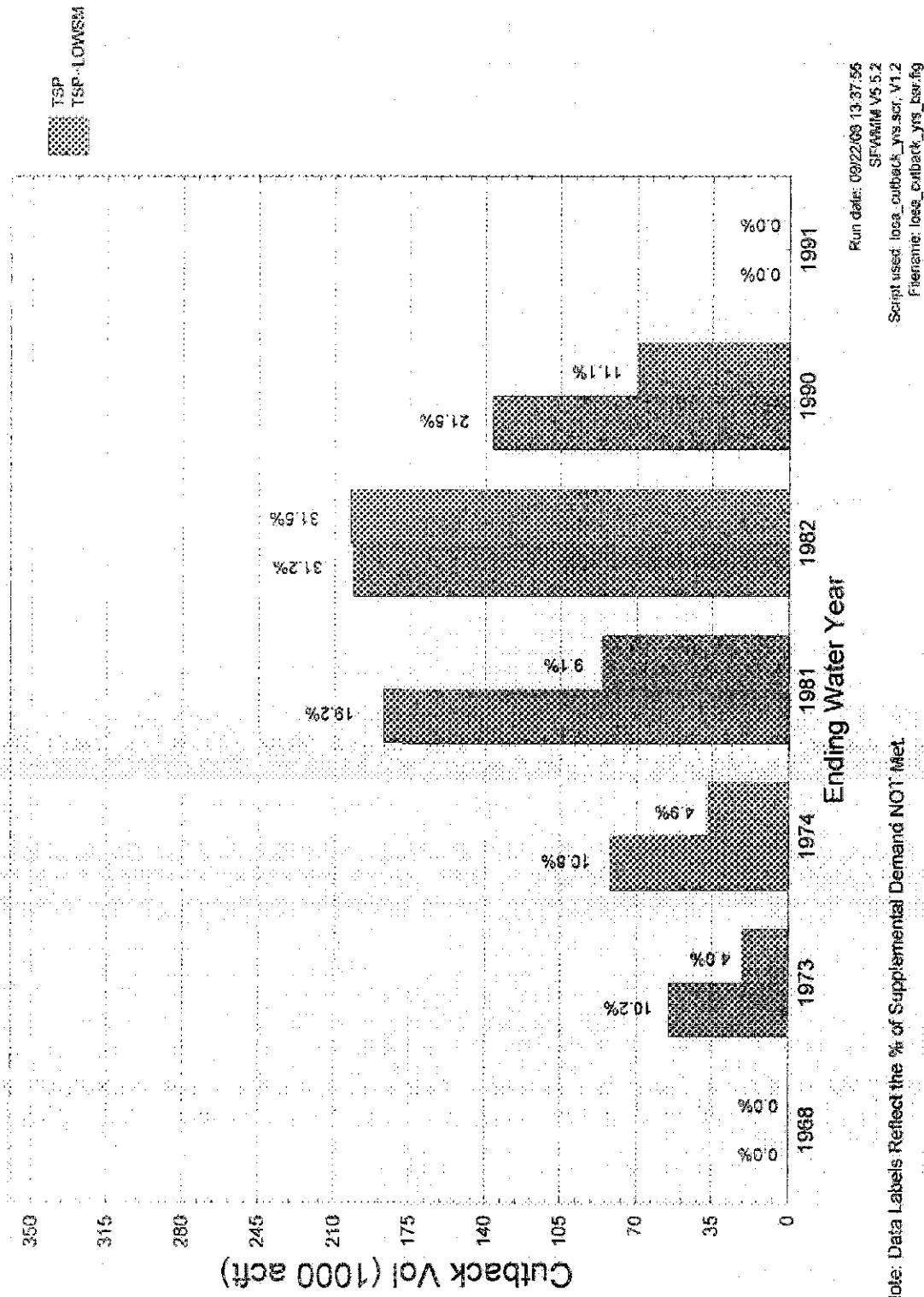


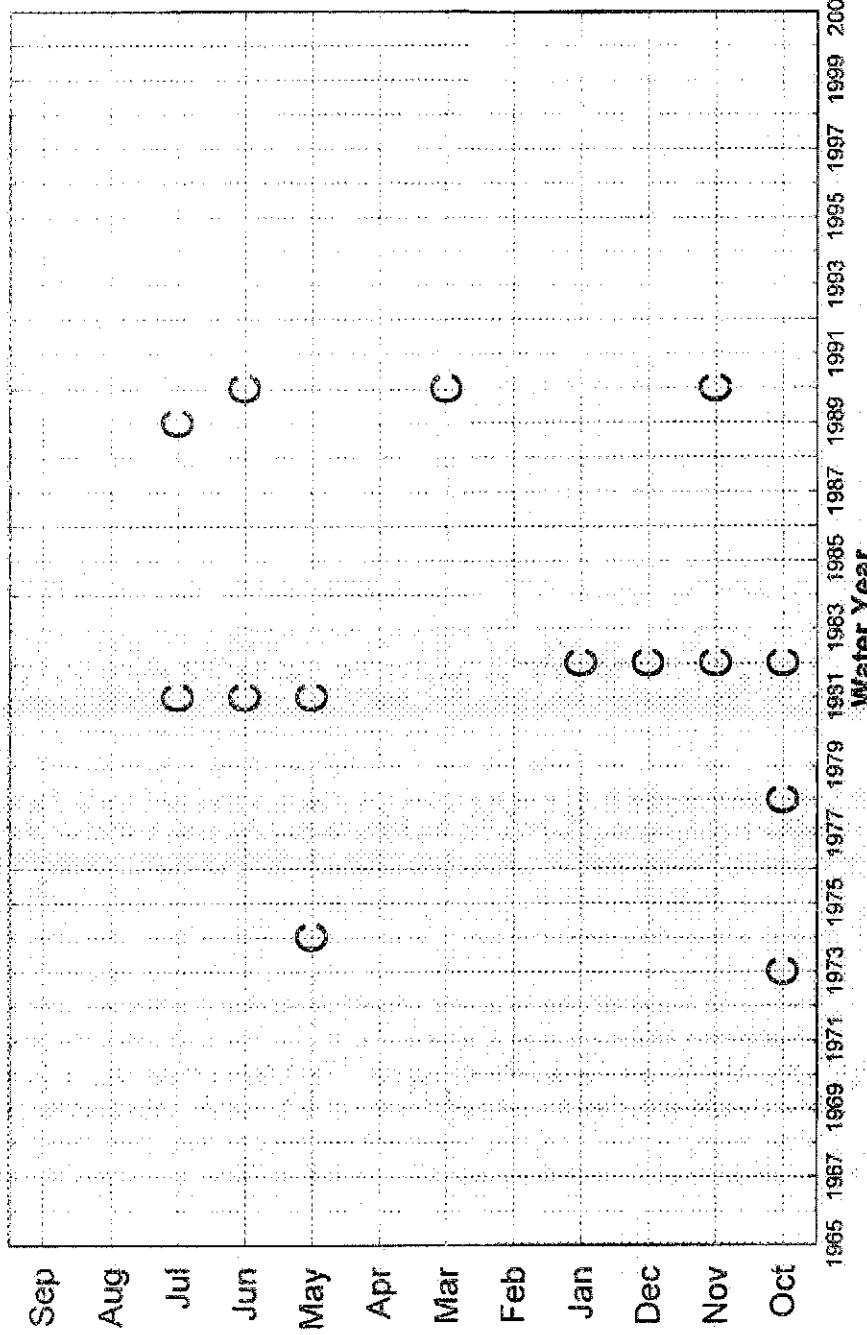
Figure 9.

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Frequency of Water Restrictions for the 1965 – 2000 Simulation Period

Lake Okeechobee Service Area - TSP



Total number of water years with restrictions = 7

C: Under Supply Side Management and Cutbacks for
7 days or more, and Cutbacks greater or equal than 10%
and 18000 ac-ft/month

Target number of water years with restrictions = 3

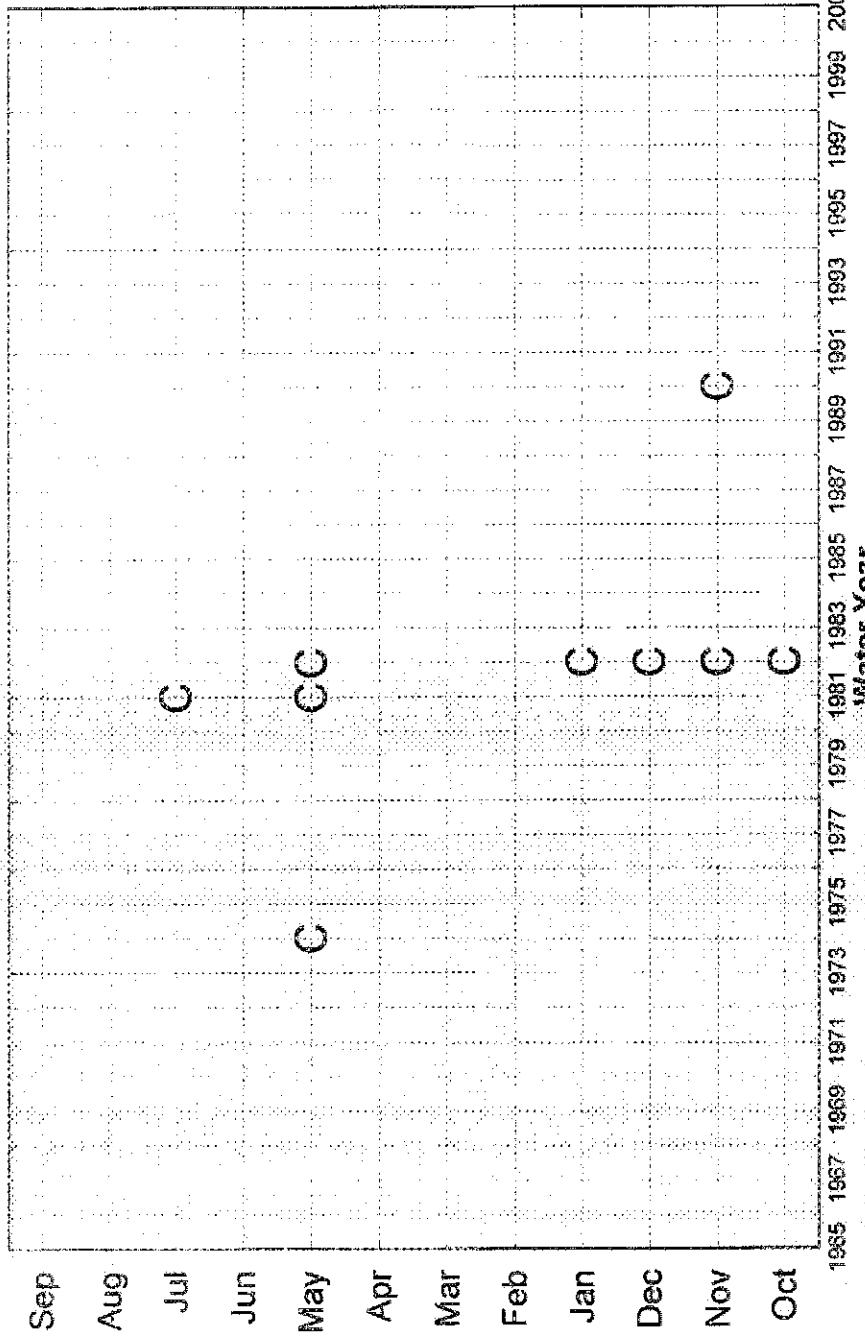
Note: Water year 1981 starts Oct 1980 and ends Sep 1981

Run date: 08/22/06 13:44:46
SF-WAMM v5.5.2
Script used: freq_water_restr.scr V1.11
Filename: losa_freq_restr.TSP.fif

Figure 10.

Frequency of Water Restrictions for the 1965 – 2000 Simulation Period

Lake Okeechobee Service Area – TSP-LOWSM



Total number of water years with restrictions= 4

G: Under Supply Side Management and Cutbacks for
7 days or more, and Cutbacks greater or equal than 10%
and 18000 ac-ft/month

Target number of water years with restrictions= 3

Note: Water year 1981 starts Oct/1980 and ends Sep/1981

Figure 11.

DRAFT

9/29/2006

Run date: 09/22/06 13:44:47
SFWMM V5.5.2
Script used: freq_water_restr.scr_V1.1
Filename: loss_freq_restr.TSP-LOWSM.fq

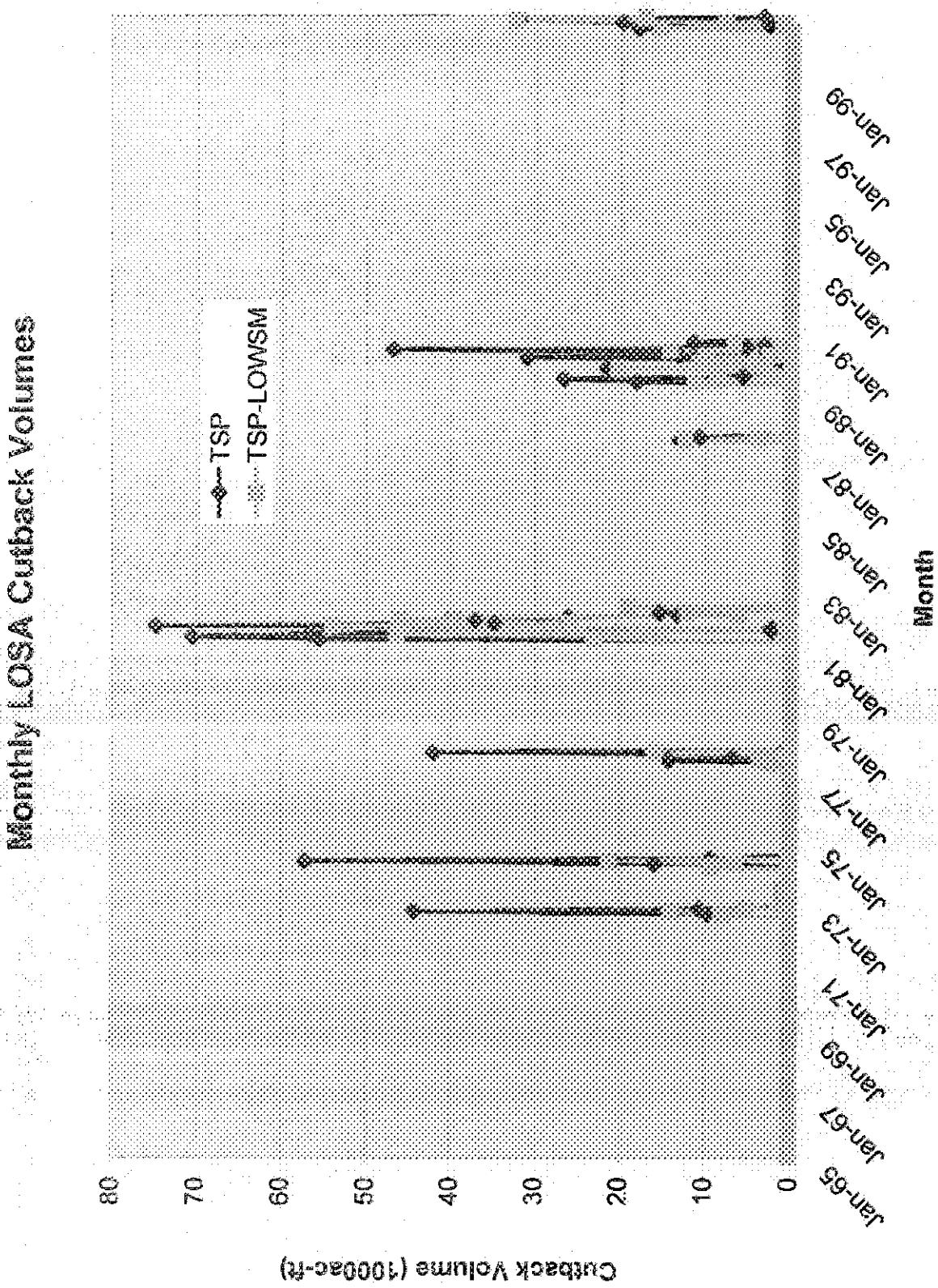


Figure 12.

DRAFT

9/29/2006

18

Number of Months of Simulated Water Supply Cutbacks for the 1965 – 2000 Simulation Period

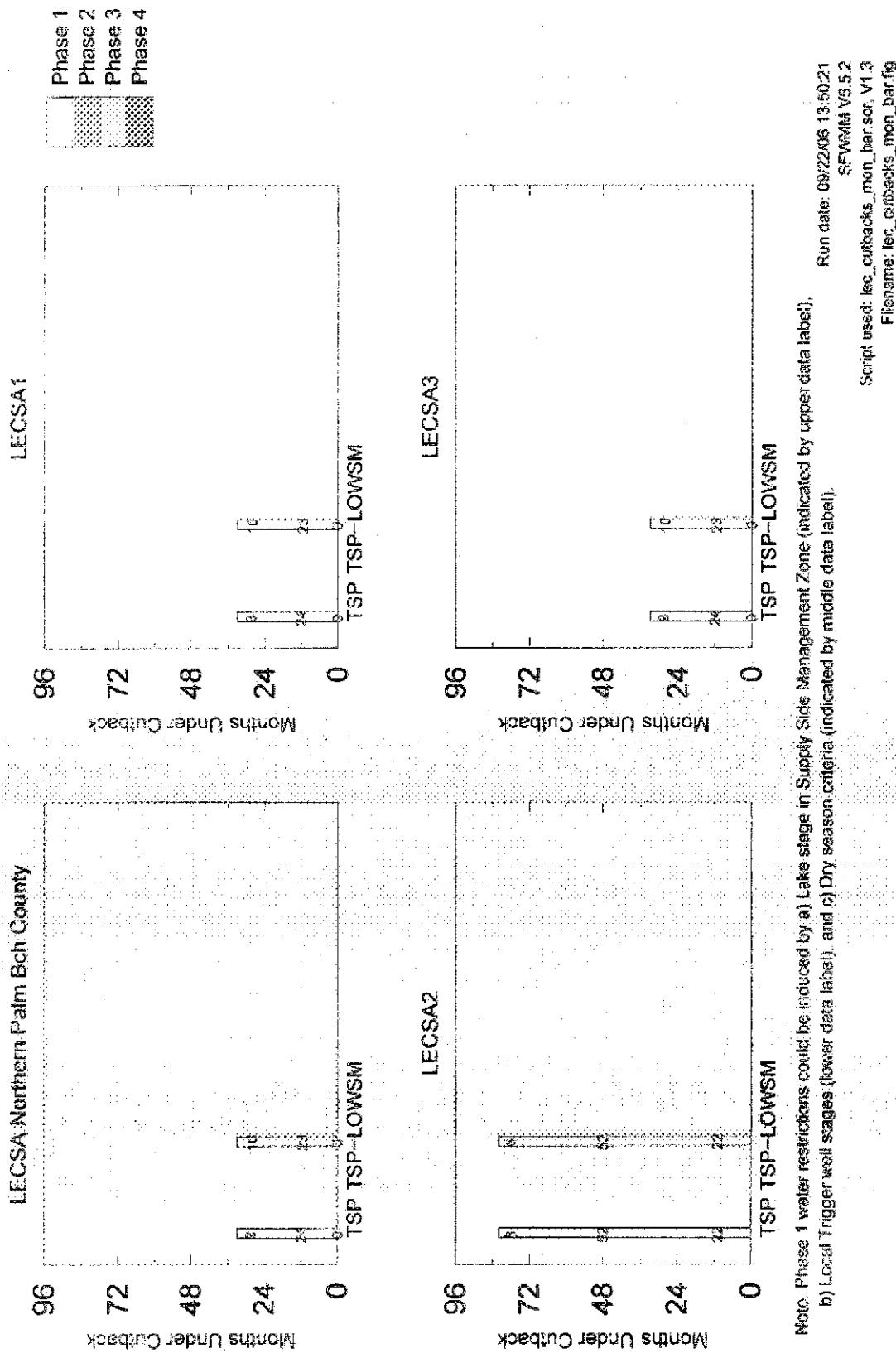
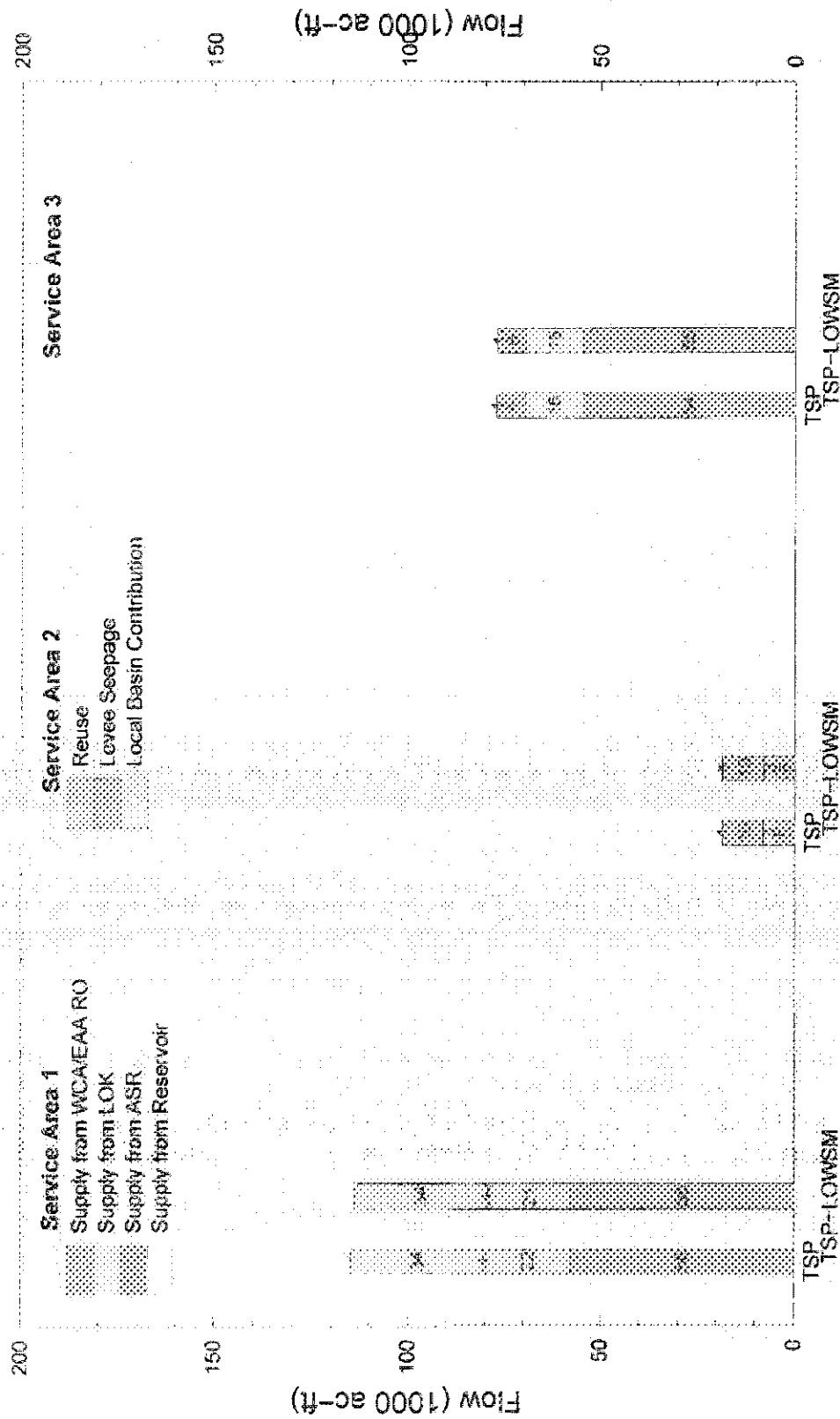


Figure 13.

DRAFT

9/29/2006

Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 – 2000 simulation

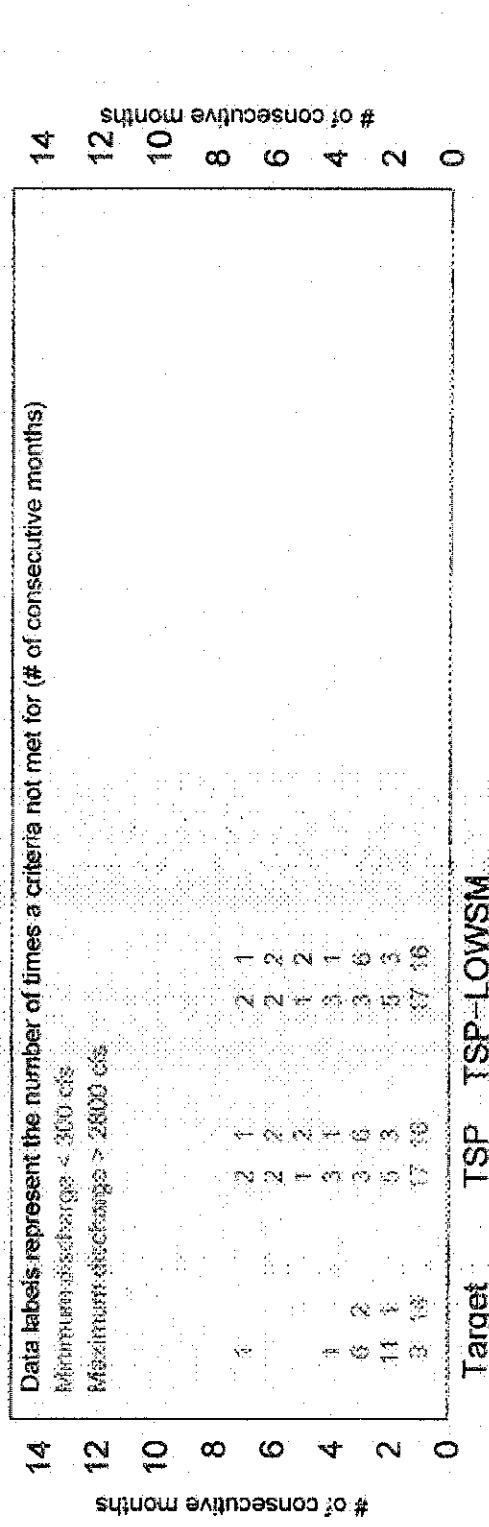
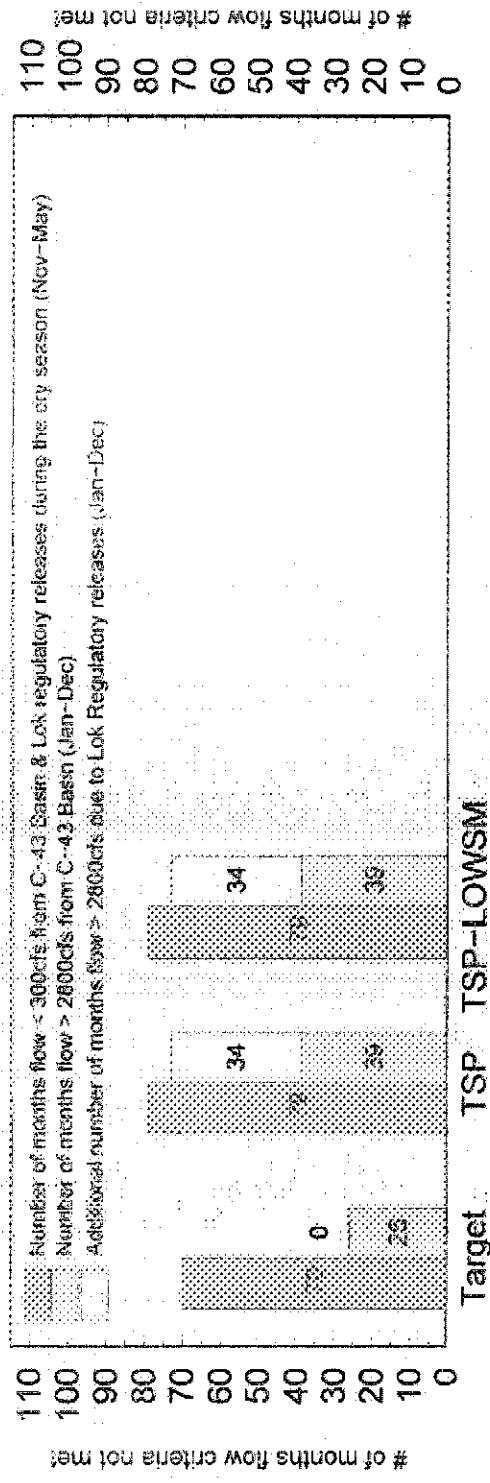


Run date: 02/22/2016 13:47:46
SFWatM V5.5.2
Script used: ws2002sa_Conn.Scr_V1.5
Filename: ws_08_bar.flg

Figure 14.
DRAFT

9/29/2006
20

Number of times Salinity Envelope Criteria NOT Met for the Caloosahatchee Estuary (mean monthly flows 1965 - 2000)



Run date: 09/22/06 13:49:13
SFWMDA V5.5.2
Script used: estuary.scr.v1.18
Filename: calcoes_salinity_flow_bar.fg

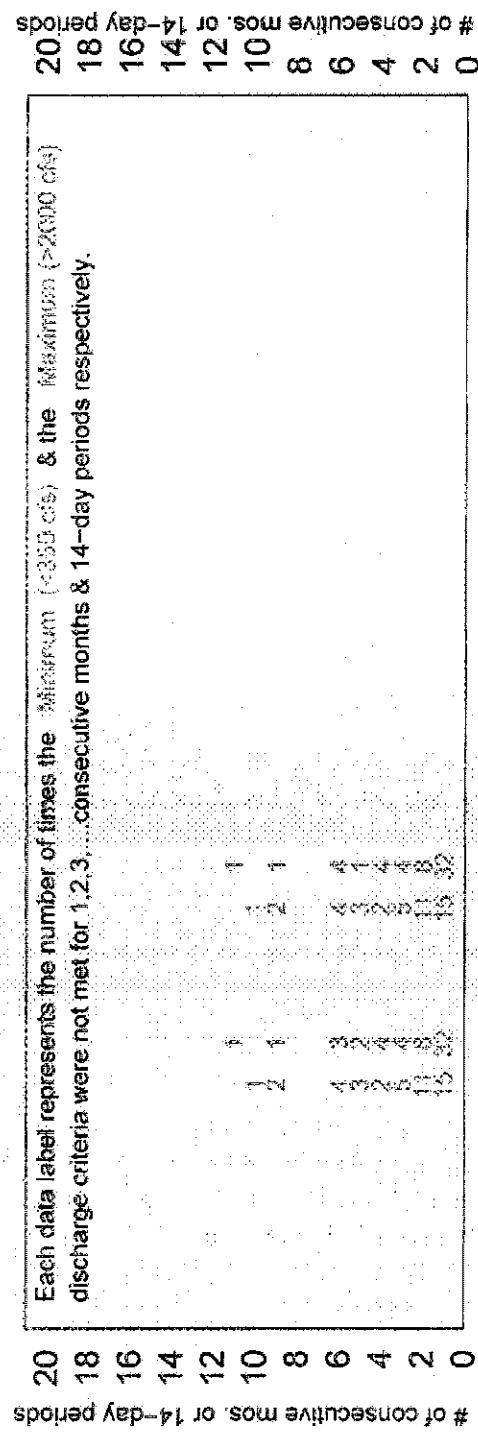
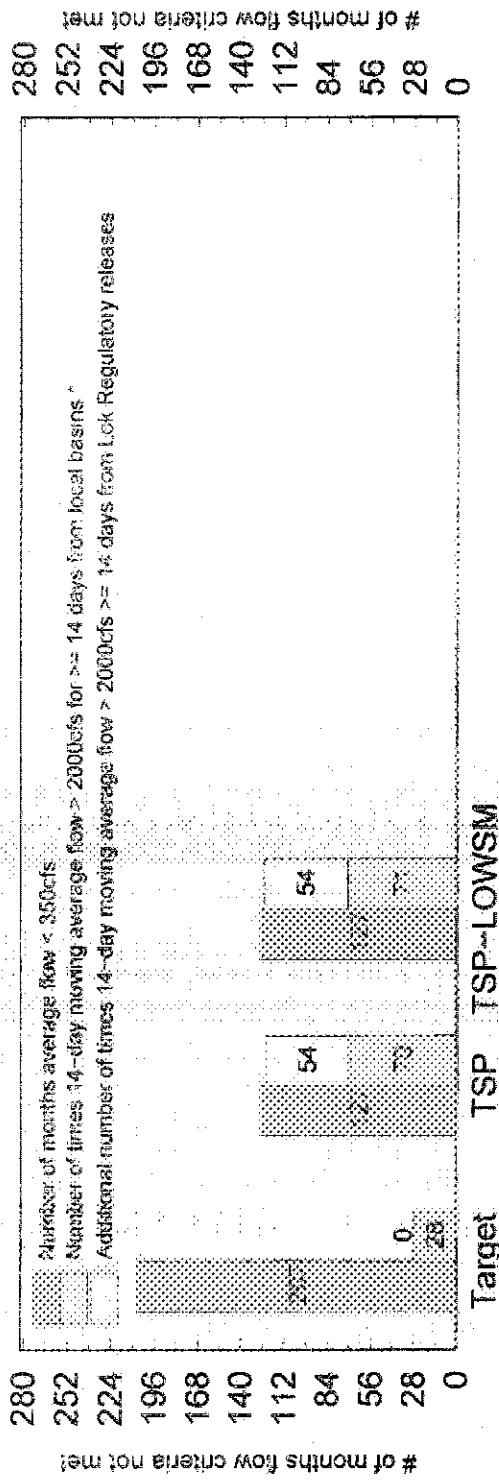
Figure 15.

DRAFT

9/29/2006

21

Number of times Salinity Envelope Criteria NOT Met for the St. Lucie Estuary (mean monthly flows 1965 - 2000)



Run date: 09/22/06 13:49:11
SFWMM vs 5.2
Script used: estuary.scs, v1.18
Filename: stuc_salinity_flow_bar.tng

Figure 16.

ATTACHMENT 2:

ATTACHMENT 2:
SFWMD Notice of Proposed Rule

WATER MANAGEMENT DISTRICTS

South Florida Water Management District

RULE NO: RULE TITLE

40E-21.521: Phase I Moderate Water Shortage

40E-21.531: Phase II Severe Water Shortage

40E-21.541: Phase III Extreme Water Shortage

40E-21.551: Phase IV Critical Water Shortage

PURPOSE AND EFFECT: To address management of available water supplies in the Lake Okeechobee Region during drought conditions.

SUMMARY: The proposed rule amendments will limit the allocations to agricultural users in the Lake Okeechobee Region during drought conditions by shifting to a phased, percentage cut-back method similar to other water use classes.

SUMMARY OF STATEMENT OF ESTIMATED REGULATORY COSTS: No Statement of Estimated Regulatory Cost was prepared.

Any person who wishes to provide information regarding a statement of estimated regulatory costs, or provide a proposal for a lower cost regulatory alternative must do so in writing within 21 days of this notice.

SPECIFIC AUTHORITY: 373.044, 373.113, F.S.

LAW IMPLEMENTED: 373.042, 373.0421, 373.175, 373.246, F.S.

IF REQUESTED WITHIN 21 DAYS OF THE DATE OF THIS NOTICE, A HEARING WILL BE HELD AT THE DATE, TIME AND PLACE SHOWN BELOW(IF NOT REQUESTED, THIS HEARING WILL NOT BE HELD):

DATE AND TIME: November 15, 2007, beginning at 9:00 a.m.

PLACE: Key Largo Marriott, 103800 Overseas Highway, Key Largo, FL 33037

Pursuant to the provisions of the Americans with Disabilities Act, any person requiring special accommodations to participate in this workshop/meeting is asked to advise the agency at least 5 days before the workshop/meeting by contacting: Clerk of the South

Florida Water Management District, (561) 682-2087, or 1 (800) 432-2045, ext. 2087. If you are hearing or speech impaired, please contact the agency using the Florida Relay Service, 1(800)955-8771 (TDD) or 1(800)955-8770 (Voice).

THE PERSON TO BE CONTACTED REGARDING THE PROPOSED RULE IS: Peter J. Kwiatkowski, P.G., South Florida Water Management District, P.O. Box 24680, West Palm Beach, FL 33416-4680, 1 (800) 432-2045, ext. 2547 or (561) 682-2547, email: pkwiat@sfwm.gov or Elizabeth D. Ross, Senior Specialist Attorney, South Florida Water Management District, P.O. Box 24680, West Palm Beach, FL 33416-4680, 1 (800) 432-2045, ext. 6257 or (561) 682-6257, email: bross@sfwm.gov. For procedural issues contact Jan Sluth, Paralegal, South Florida Water Management District, P.O. Box 24680, West Palm Beach, FL 33416-4680, 1 (800) 432-2045, ext 6299 or (561) 682-6299, email: jsluth@sfwm.gov.

THE FULL TEXT OF THE PROPOSED RULE IS:

40E-21.521 Phase I Moderate Water Shortage.

(1) (a) through (e) No change.

(f) Diversion and Impoundment into Non-District Facilities. Water used for diversion and impoundment into non-District facilities shall be voluntarily reduced; however, the diversion of surface water from sources in the Lake Okeechobee Region as depicted on Figure 21-4 and described in subsection 40E-21.691(3), F.A.C., shall be subject to the restrictions described in subparagraph (2)(a)6., below.

(2) Agriculture.

(a) Agricultural Use:

1. through 5. No change.

6. The District's allocation determination for agricultural irrigation within the entire Lake Okeechobee Region as depicted on Figure 21-4 will be based on 15% cutbacks to the calculated 1 in 10 supplemental crop demands calculated on a weekly

basis. The entire Lake Okeechobee Region supplemental crop demands will be distributed among the sub-basins depicted in Figure 21-4 based on a grouping of crop types, irrigation methods (e.g. flood irrigated crops versus micro irrigated crops), the associated acreage totals as identified in the individual water use permits combined with the associated 1 in 10 evapotranspiration demands of the crops. An additional amount of water from Lake Okeechobee will be added to the weekly allocation as necessary to account for conveyance losses that occur through seepage and free surface evaporation from the Central and Southern Florida Flood Control System Project canals. The share of the entire Lake Okeechobee Region irrigation allocation available to each sub-basin may be further adjusted to prioritize water deliveries among crops, as long as the sum of the sub-basin allocations does not exceed the weekly allocation for the entire Lake Okeechobee Region and that equity among users and sub-basins is assured. Such adjustments shall be based upon irrigation efficiency, potential for economic loss, and acreage irrigated as opposed to non-irrigated acreage. Withdrawals by each permitted user within the Lake Okeechobee Region as described in subsection 40E-21.691(3), F.A.C., shall be limited to an amount that represents each user's share of their sub-basin weekly allocation based on their permitted crop type and irrigated acreage the total allocation for agricultural irrigation made by the District from Lake Okeechobee (Lake) for that month and in that basin. The District shall provide the users with the data necessary to calculate their weekly allotment of water. The District's allocation determination for agricultural irrigation within the Lake Okeechobee Region will be based on its evaluation of the supply capabilities of the source class, the supply capabilities of other source classes available in the area, the needs of agriculture and other users in the area, and the District's overall management strategy for handling the uncertainties of future climatological events. The share of the total agricultural irrigation allocation available to each user will be based on any prioritization among crops the District establishes based on irrigation efficiency, economic loss and equity considerations, and the acreage and quantity of withdrawals for which the user has been permitted. The District's allocation determination for agricultural irrigation within the Lake Okeechobee Region will be based on the supply capacity of Lake Okeechobee assuming a June 1st lake stage of 10.5 feet NGVD.

(2) (b) through (e) No change.

(3) through (4) No change.

Specific Authority 373.044, 373.113 FS. Law Implemented 373.042, 373.0421, 373.175, 373.246 FS. History—New 5-31-82, Amended 1-26-86, 2-14-91, 9-10-01, _____.

40E-21.531 Phase II Severe Water Shortage.

(1)(a) through (e) No change.

(f) Diversion and Impoundment into Non-District Facilities. 4. Water used for diversion and impoundment into non-District facilities shall be voluntarily reduced; however, the diversion of surface water from sources in the Lake Okeechobee Region as depicted on Figure 21-4 and described in subsection 40E-21.691(3), F.A.C., shall be subject to the restrictions described in subparagraph (2)(a)6., below.

(2) Agriculture.

(a) Agricultural Use.

1. through 5. No change.

6. The District's allocation determination for agricultural irrigation within the entire Lake Okeechobee Region as depicted on Figure 21-4 will be based on 30% cutbacks to the calculated 1 in 10 supplemental crop demands calculated on a weekly basis. The entire Lake Okeechobee Region supplemental crop demands will be distributed among the sub-basins depicted in Figure 21-4 based on a grouping of crop types, irrigation methods (e.g. flood irrigated crops versus micro irrigated crops), the associated acreage totals as identified in the individual water use permits combined with the associated 1 in 10 evapotranspiration demands of the crops. An additional amount of water from Lake Okeechobee will be added to the weekly allocation as necessary to account for conveyance losses that occur through seepage and free surface evaporation from the Central and Southern Florida Flood Control System Project canals. The share of the entire Lake Okeechobee Region irrigation allocation available to each sub-basin may

be further adjusted to prioritize water deliveries among crops, as long as the sum of the sub-basin allocations does not exceed the weekly allocation for the entire Lake Okeechobee Region and that equity among users and sub-basins is assured. Such adjustments shall be based upon irrigation efficiency, potential for economic loss, and acreage irrigated as opposed to non-irrigated acreage. Withdrawals by each permitted user within the Lake Okeechobee Region as described in subsection 40E-21.691(3), F.A.C., shall be limited to an amount that represents each user's share of their sub-basin weekly allocation based on their permitted crop type and irrigated acreage the total allocation for agricultural irrigation made by the District from Lake Okeechobee (Lake) for that month and in that basin. The District shall provide the users with the data necessary to calculate their weekly allotment of water. The District's allocation determination for agricultural irrigation within the Lake Okeechobee Region will be based on its evaluation of the supply capabilities of the source class, the supply capabilities of other source classes available in the area, the needs of agriculture and other users in the area, and the District's overall management strategy for handling the uncertainties of future climatological events. The share of the total agricultural irrigation allocation available to each user will be based on any prioritization among crops the District establishes based on irrigation efficiency, economic loss and equity considerations, and the acreage and quantity of withdrawals for which the user has been permitted. The District's allocation determination for agricultural irrigation within the Lake Okeechobee Region will be based on the supply capacity of Lake Okeechobee assuming a June 1st lake stage of 10.5 feet NGVD.

(2) (b) through (e) No change.

(3) through (4) No change.

Specific Authority 373.044, 373.113 FS. Law Implemented 373.042, 373.0421, 373.175, 373.246 FS. History—New 5-31-82, Amended 1-26-86, 2-14-91, 9-10-01, _____.

40E-21.541 Phase III Extreme Water Shortage.

(1) (a) through (e) No change.

(f) Diversion and Impoundment into Non-District Facilities. 4. Water used for diversion and impoundment into non-District facilities shall be voluntarily reduced; however, the diversion of surface water from sources in the Lake Okeechobee Region as depicted on Figure 21-4 and described in subsection 40E-21.691(3), F.A.C., shall be subject to the restrictions described in subparagraph (2)(a)6., below.

(2) Agriculture.

(a) Agricultural Use.

1. through 4. No Change.

5. The District's allocation determination for agricultural irrigation within the entire Lake Okeechobee Region as depicted on Figure 21-4 will be based on 45% cutbacks to the calculated 1 in 10 supplemental crop demands calculated on a weekly basis. The entire Lake Okeechobee Region supplemental crop demands will be distributed among the sub-basins depicted in Figure 21-4 based on a grouping of crop types, irrigation methods (e.g. flood irrigated crops versus micro irrigated crops), the associated acreage totals as identified in the individual water use permits combined with the associated 1 in 10 evapotranspiration demands of the crops. An additional amount of water from Lake Okeechobee will be added to the weekly allocation as necessary to account for conveyance losses that occur through seepage and free surface evaporation from the Central and Southern Florida Flood Control System Project canals. The share of the entire Lake Okeechobee Region irrigation allocation available to each sub-basin may be further adjusted to prioritize water deliveries among crops, as long as the sum of the sub-basin allocations does not exceed the weekly allocation for the entire Lake Okeechobee Region and that equity among users and sub-basins is assured. Such adjustments shall be based upon irrigation efficiency, potential for economic loss, and acreage irrigated as opposed to non-irrigated acreage. Withdrawals by each user within the Lake Okeechobee Region as described in subsection 40E-21.691(3), F.A.C., from each source class in each month shall be limited to an amount that represents each user's share of their sub-basin weekly allocation based on their permitted crop type and irrigated acreage the total allocation for agricultural irrigation made by the District from that

source for that month and in that basin. The District shall provide the users with the data necessary to calculate their weekly allotment of water. The District's allocation determination for agricultural irrigation will be based on its evaluation of the supply capabilities of the source class, the supply capabilities of other source classes available in the area, the needs of agriculture and all other users in the area, and the District's overall management strategy for handling the uncertainties of future climatological events. The share of the total agricultural irrigation allocation available to each user will be based on any prioritization among crops the District establishes based on irrigation efficiency, economic loss and equity considerations and the acreage and quantity of withdrawals for which the user has been permitted. The District's allocation determination for agricultural irrigation within the Lake Okeechobee Region, as described in subsection 40E-21.691(3), F.A.C., will be based on the supply capacity of Lake Okeechobee as defined by the establishment of a temporary reference elevation.

- a. The short and long term harm to the water resources and economy associated with further reduction in Lake stage;
- b. The harm to the crops, and associated economic impacts, projected to result from the reduction or elimination of water supply; and
- c. The projected drought duration.

The day to day operational decisions associated with implementing the temporary revised reference elevation shall be delegated to staff in the Phase III water shortage order. The governing board will be updated on a monthly basis at a governing board or other public meeting of past and projected changes to the temporary revised reference elevation.

6. (b) through (e) No change.

(3) through (4) No change.

Specific Authority 373.044, 373.113 FS. Law Implemented 373.042, 373.0421, 373.175, 373.246 FS. History—New 5-31-82, Amended 1-26-86, 2-14-91, 9-10-01, _____.

40E-21.551 Phase IV Critical Water Shortage.

(1) (a) through (e) No change.

(f) Diversion and Impoundment into Non-District Facilities. 4. Water used for diversion and impoundment into non-District facilities shall be voluntarily reduced; however, the diversion of surface water from sources in the Lake Okeechobee Region as depicted on Figure 21-4 and described in subsection 40E-21.691(3), F.A.C., shall be subject to the restrictions described in subparagraph (2)(a)6., below.

(2) Agriculture.

(a) Agricultural Use.

1. through 4. No change.

5. The District's allocation determination for agricultural irrigation within the entire Lake Okeechobee Region as depicted on Figure 21-4 will be based on 60% cutbacks to the calculated 1 in 10 supplemental crop demands calculated on a weekly basis. The entire Lake Okeechobee Region supplemental crop demands will be distributed among the sub-basins depicted in Figure 21-4 based on a grouping of crop types, irrigation methods (e.g. flood irrigated crops versus micro irrigated crops), the associated acreage totals as identified in the individual water use permits combined with the associated 1 in 10 evapotranspiration demands of the crops. An additional amount of water from Lake Okeechobee will be added to the weekly allocation as necessary to account for conveyance losses that occur through seepage and free surface evaporation from the Central and Southern Florida Flood Control System Project canals. The share of the entire Lake Okeechobee Region irrigation allocation available to each sub-basin may be further adjusted to prioritize water deliveries among crops, as long as the sum of the sub-basin allocations does not exceed the weekly allocation for the entire Lake Okeechobee Region and that equity among users and sub-basins is assured. Such adjustments shall be based upon irrigation efficiency, potential for economic loss, and acreage irrigated as opposed to non-irrigated acreage. Withdrawals by each user within the Lake Okeechobee Region as described in subsection 40E-21.691(3), F.A.C., from

~~each source class in each month shall be limited to an amount that represents each user's share of their sub-basin weekly allocation based on their permitted crop type and irrigated acreage the total allocation for agricultural irrigation made by the District from that source for that month and in that basin. The District shall provide the users with the data necessary to calculate their weekly allotment of water. The District's allocation determination for agricultural irrigation will be based on its evaluation of the supply capabilities of the source class, the supply capabilities of other source classes available in the area, the needs of agriculture and all other users in the area, and the District's overall management strategy for handling the uncertainties of future climatological events. The share of the total agricultural irrigation allocation available to each user will be based on any prioritization among crops the District establishes based on economic loss and equity considerations and the acreage and quantity of withdrawals for which the user has been permitted.~~

6.(b) through (e) No change.

(3) through (4) No change.

Specific Authority 373.044, 373.113 FS. Law Implemented 373.175, 373.246 FS.

History—New 5-31-82, Amended 1-26-86, 2-14-91, _____.

Lake Okeechobee Region Sub-Basin Boundaries

- A: NORTHEAST LAKE SHORE
- B: ST. LUCIE (C-44)
- C: WPB CANAL & L-8
- D: E. BEACH & E. SHORE WCD
- E: N. NEW RIVER & HILLSBORO
- F: MIAMI CANAL BASIN
- G: C-21 & S-236 BASINS
- H: CALOOSA HATCHEE (C-43)
- I: NORTHWEST LAKE SHORE
- J: NORTH LAKE SHORE

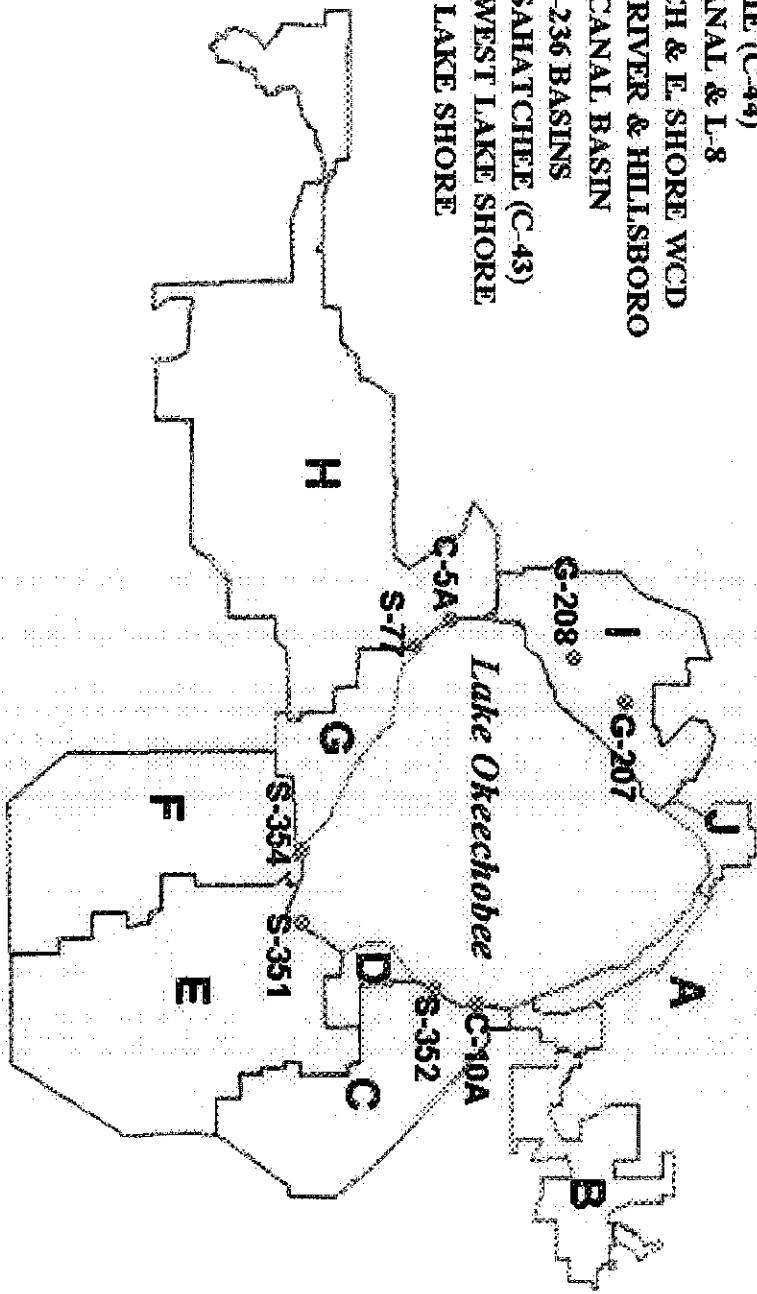


Figure 21-4

NAME OF PERSON ORIGINATING PROPOSED RULE: Peter J. Kwiatkowski, P.G.

NAME OF SUPERVISOR OR PERSON WHO APPROVED THE PROPOSED RULE:

South Florida Water Management District Governing Board

DATE PROPOSED RULE APPROVED BY AGENCY HEAD: September 13, 2007

DATE NOTICE OF PROPOSED RULE DEVELOPMENT PUBLISHED IN FAW:

August 17, 2007